Ilmenau University of Technology
Faculty of Computer Science and Automation

# A System of Autonomously Flying Helicopters for Load Transportation

**Additional Equations**

Markus Bernard

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Doctoral Adviser: Prof. Dr.-Ing. Armin Zimmermann
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# Contents

# 1 Blade angle calculation, including the Bell-Hiller-Bar

The following equations describe the relation between the swash plate angle $\alpha_{\mathrm{fl}}^{\mathrm{SP}}$, the Bell-Hiller-Bar angle $\gamma_{\mathrm{mr1}}^{\mathrm{BHB}}$ and the main-rotor blade angle $\alpha_{\mathrm{mr1}}^{\mathrm{BL}}$:

$$
\begin{aligned}
h_0 &= -l_3 - l_7 \\
h_1 &= -l_7 \\
h_2 &= 0 \\
x_{1,3} &= x_1 - x_3 \\
y_{1,3} &= y_1 - y_3 \\
x_0 &= \sin\left(\alpha_{\mathrm{fl}}^{\mathrm{SP}}\right)(l_1 + l_2) \\
y_0 &= \cos\left(\alpha_{\mathrm{fl}}^{\mathrm{SP}}\right)(l_1 + l_2) - l_3 - l_7 \\
x_1 &= \sin\left(\alpha_{\mathrm{fl}}^{\mathrm{SP}}\right) l_1 \\
y_1 &= \cos\left(\alpha_{\mathrm{fl}}^{\mathrm{SP}}\right) l_1 - l_3 - l_7 \\
x_2 &= \Bigg( -l_3^2\, x_{1,3}^2 + \left(x_{1,3}\, l_5^2 + 2 l_6\, x_{1,3}\, l_5 + l_6^2\, x_{1,3} + (x_1 + x_3)\left(x_{1,3}^2 + y_{1,3}^2\right)\right) x_{1,3} + \\
&\quad \sqrt{-x_{1,3}^2 \left(l_3^4 - 2\left(\left(l_5 + l_6\right)^2 + x_{1,3}^2 + y_{1,3}^2\right) l_3^2 + \left(-\left(l_5 + l_6\right)^2 + x_{1,3}^2 + y_{1,3}^2\right)^2\right)} \\
&\quad (y_3 - y_1)\Bigg) \Big/ \left(2\, x_{1,3}^3 + 2\, x_{1,3}\, y_{1,3}^2\right) \\
y_2 &= \Bigg( (y_3 - y_1)\, l_3^2 + l_5^2\, y_{1,3} + l_6^2\, y_{1,3} + 2\, l_5\, l_6\, y_{1,3} + (y_1 + y_3)\left(x_{1,3}^2 + y_{1,3}^2\right) + \\
&\quad \sqrt{-x_{1,3}^2 \left(l_3^4 - 2\left(\left(l_5 + l_6\right)^2 + x_{1,3}^2 + y_{1,3}^2\right) l_3^2 + \left(-\left(l_5 + l_6\right)^2 + x_{1,3}^2 + y_{1,3}^2\right)^2\right)} \Bigg) \\
&\quad \Big/ \left(2\, x_{1,3}^2 + 2\, y_{1,3}^2\right)
\end{aligned}
$$

$$
\begin{aligned}
x_3 &= \sin\left(\gamma_{\mathrm{mr1}}^{\mathrm{BHB}}\right)\left(l_4 + l_5 + l_6\right) \\
y_3 &= \cos\left(\gamma_{\mathrm{mr1}}^{\mathrm{BHB}}\right)\left(l_4 + l_5 + l_6\right) - l_7 \\
x_4 &= \left(l_6\, x_2 + l_5\, x_3\right)/\left(l_5 + l_6\right) \\
y_4 &= \left(l_6\, y_2 + l_5\, y_3\right)/\left(l_5 + l_6\right) \\
x_5 &= -\left(y_4\sqrt{-x_4^2\left(l_7^4 - 2\left(l_8^2 + x_4^2 + y_4^2\right)l_7^2 + \left(-l_8^2 + x_4^2 + y_4^2\right)^2\right)} + \right. \\
&\qquad \left. l_7^2\, x_4^2 - \left(l_8^2 + x_4^2 + y_4^2\right)\, x_4^2\right)/\left(2\, x_4^3 + 2 x_4\, y_4^2\right) \\
y_5 &= \left(\sqrt{-x_4^2\left(l_7^4 - 2\left(l_8^2 + x_4^2 + y_4^2\right)l_7^2 + \left(-l_8^2 + x_4^2 + y_4^2\right)^2\right)} + \right. \\
&\qquad \left. y_4\left(-l_7^2 + l_8^2 + x_4^2 + y_4^2\right)\right)/\left(2\, x_4^2 + 2\, y_4^2\right) \\
\alpha_{\mathrm{mr1}}^{\mathrm{BL}} &= \mathrm{arctan2}\left(-y_5,\, x_5\right)
\end{aligned}
$$

The constants $l_x$ are described in the thesis main document [Ber13, pages 38ff.]. The coordinates $(x_u,\, y_u)$ belong to intermediate points taken relative to a local coordinate system.

# 2 Dynamic Equations of a Single Helicopter

In the following, the complete dynamic equations of a single helicopter are presented. The variables $z_{xyz}$ are intermediate results, which are generated automatically. The result of the Kane method is the following set of equations:

$$0 = z_{50} + z_{74}\,\dot{w} - z_{79} - z_{73}\,\dot{r} - z_{75}\,\dot{q} - z_{76}\,\dot{u} - z_{77}\,\dot{v} - z_{78}\,\dot{p}$$

$$0 = z_{51} + z_{81}\,\dot{w} - z_{85} - z_{77}\,\dot{u} - z_{80}\,\dot{r} - z_{82}\,\dot{q} - z_{83}\,\dot{v} - z_{84}\,\dot{p}$$

$$0 = z_{52} + z_{74}\,\dot{u} + z_{81}\,\dot{v} - z_{90} - z_{86}\,\dot{r} - z_{87}\,\dot{w} - z_{88}\,\dot{q} - z_{89}\,\dot{p}$$

$$0 = z_{55} - z_{94} - z_{91}\,\dot{p} - z_{92}\,\dot{r} - z_{93}\,\dot{q} - z_{78}\,\dot{u} - z_{84}\,\dot{v} - z_{89}\,\dot{w}$$

$$0 = z_{57} - z_{97} - z_{93}\,\dot{p} - z_{95}\,\dot{q} - z_{96}\,\dot{r} - z_{75}\,\dot{u} - z_{82}\,\dot{v} - z_{88}\,\dot{w}$$

$$0 = z_{58} - z_{99} - z_{92}\,\dot{p} - z_{96}\,\dot{q} - z_{98}\,\dot{r} - z_{73}\,\dot{u} - z_{80}\,\dot{v} - z_{86}\,\dot{w}$$

The equations need to be solved for the desired variables ($\dot{u}$, $\dot{v}$, $\dot{w}$, $\dot{p}$, $\dot{q}$, $\dot{r}$). It is possible to use Gaussian elimination to get an explicit solution, since the equations are linear with respect to the desired variables. It should be noted that result may contain singularities, since e.g. a division through a $z_{xyz}$ variable might become a division through zero. Solving the equations numerically during simulation, using e.g. Singular Value Decomposition (SVD), is another possibility, which avoids those singularities. The following equations describe the $z_{xyz}$ variables, which had not been defined until now:

$$z_1 = \pi + \psi$$

$$z_2 = \pi + \theta$$

$$z_3 = \cos(z_1)$$

$$z_4 = \cos(z_2)$$

$$z_5 = z_3\, z_4$$

$$z_6 = \sin(\varphi)$$

$$z_7 = \sin(z_2)$$

$$z_8 = \cos(\varphi)$$

$$z_9 = \sin(z_1)$$

$$
\begin{aligned}
z_{10} &= z_3\, z_6\, z_7 \; - z_8\, z_9 \\
z_{11} &= z_6\, z_9 \; + z_3\, z_7\, z_8 \\
z_{12} &= z_4\, z_9 \\
z_{13} &= z_3\, z_8 \; + z_6\, z_7\, z_9 \\
z_{14} &= z_7\, z_8\, z_9 \; - z_3\, z_6 \\
z_{15} &= z_4\, z_6 \\
z_{16} &= z_4\, z_8 \\
z_{23} &= \omega_{MR} + r \\
z_{24} &= q(r - z_{23}\,) \\
z_{25} &= p(r - z_{23}\,) \\
z_{26} &= m_F + m_{MR} \\
z_{27} &= (dOFo_1 m_F + dOMRo_1 m_{MR})/z_{26} \\
z_{28} &= (dOFo_2 m_F + dOMRo_2 m_{MR})/z_{26} \\
z_{29} &= (dOFo_3 m_F + dOMRo_3 m_{MR})/z_{26} \\
z_{30} &= dOMRo_1 - z_{27} \\
z_{31} &= dOMRo_2 - z_{28} \\
z_{32} &= dOMRo_3 - z_{29} \\
z_{33} &= dOFo_1 - z_{27} \\
z_{34} &= dOFo_2 - z_{28} \\
z_{35} &= dOFo_3 - z_{29} \\
z_{36} &= dOT_1 - z_{27} \\
z_{38} &= dOT_3 - z_{29} \\
z_{39} &= -q(z_{30}\, q - z_{31}\, p) - r(z_{30}\, r - z_{32}\, p) \\
z_{40} &= p(z_{30}\, q - z_{31}\, p) - r(z_{31}\, r - z_{32}\, q) \\
z_{41} &= p(z_{30}\, r - z_{32}\, p) + q(z_{31}\, r - z_{32}\, q) \\
z_{42} &= -q(z_{33}\, q - z_{34}\, p) - r(z_{33}\, r - z_{35}\, p) \\
z_{43} &= p(z_{33}\, q - z_{34}\, p) - r(z_{34}\, r - z_{35}\, q) \\
z_{44} &= p(z_{33}\, r - z_{35}\, p) + q(z_{34}\, r - z_{35}\, q) \\
z_{48} &= g\, m_F \\
z_{49} &= g\, m_{MR} \\
z_{50} &= F_3^{MR} z_{11} + F_2^{TR} z_{10} + z_{49}\, z_5\, z_7 + z_{48}\,(z_5\, z_7 - z_{10}\, z_{15} - z_{11}\, z_{16}\,) - z_{49}\, z_{10}\, z_{15} - z_{49}\, z_{11}\, z_{16}
\end{aligned}
$$

$$
\begin{aligned}
z_{51} &= F_3^{MR} z_{14} + F_2^{TR} z_{13} + z_{49}\, z_7\, z_{12} \\
&\quad + z_{48}\,(z_7\, z_{12} - z_{13}\, z_{15} - z_{14}\, z_{16}) - z_{49}\, z_{13}\, z_{15} - z_{49}\, z_{14}\, z_{16} \\
z_{52} &= F_3^{MR} z_{16} + F_2^{TR} z_{15} - z_{49}\, z_7^2 - z_{49}\, z_{15}^2 - z_{49}\, z_{16}^2 - z_{48}\,(z_7^2 + z_{15}^2 + z_{16}^2) \\
z_{53} &= z_{32}\, z_{49} \\
z_{54} &= z_{31}\, z_{49} \\
z_{55} &= T_1^{MR} + z_{31}\, F_3^{MR} + z_{53}\, z_{15} - z_{38}\, F_2^{TR} - z_{54}\, z_{16} - z_{48}\,(z_{34}\, z_{16} - z_{35}\, z_{15}) \\
z_{56} &= z_{30}\, z_{49} \\
z_{57} &= T_2^{MR} + T_2^{TR} + z_{53}\, z_7 + z_{56}\, z_{16} + z_{48}\,(z_{33}\, z_{16} + z_{35}\, z_7) - z_{30}\, F_3^{MR} \\
z_{58} &= T_3^{MR} + z_{36}\, F_2^{TR} - z_{48}\,(z_{33}\, z_{15} + z_{34}\, z_7) - z_{49}\,(z_{30}\, z_{15} + z_{31}\, z_7) \\
z_{59} &= I_{11}^F p \\
z_{60} &= I_{22}^F q \\
z_{61} &= I_{33}^F r \\
z_{62} &= p z_{60} - q z_{59} \\
z_{63} &= r z_{59} - p z_{61} \\
z_{64} &= q z_{61} - r z_{60} \\
z_{65} &= I_{11}^{MR} p \\
z_{66} &= I_{22}^{MR} q \\
z_{67} &= I_{33}^{MR} z_{23} \\
z_{68} &= I_{11}^{MR} z_{24} \\
z_{69} &= I_{22}^{MR} z_{25} \\
z_{70} &= p z_{66} - q z_{65} \\
z_{71} &= z_{23}\, z_{65} - p z_{67} \\
z_{72} &= q z_{67} - z_{23}\, z_{66} \\
z_{73} &= m_F(z_{33}\, z_{10} - z_{34}\, z_5) + m_{MR}(z_{30}\, z_{10} - z_{31}\, z_5) \\
z_{74} &= z_{26}\,(z_5\, z_7 - z_{10}\, z_{15} - z_{11}\, z_{16}) \\
z_{75} &= -m_F(z_{33}\, z_{11} - z_{35}\, z_5) - m_{MR}(z_{30}\, z_{11} - z_{32}\, z_5) \\
z_{76} &= z_{26}\,(z_5^2 + z_{10}^2 + z_{11}^2) \\
z_{77} &= z_{26}\,(z_5\, z_{12} + z_{10}\, z_{13} + z_{11}\, z_{14}) \\
z_{78} &= m_F(z_{34}\, z_{11} - z_{35}\, z_{10}) + m_{MR}(z_{31}\, z_{11} - z_{32}\, z_{10})
\end{aligned}
$$

$$z_{79} = m_F(z_5\, z_{42} + z_{10}\, z_{43} + z_{11}\, z_{44}) + m_{MR}(z_5\, z_{39} + z_{10}\, z_{40} + z_{11}\, z_{41})$$

$$z_{80} = m_F(z_{33}\, z_{13} - z_{34}\, z_{12}) + m_{MR}(z_{30}\, z_{13} - z_{31}\, z_{12})$$

$$z_{81} = z_{26}\,(z_7\, z_{12} - z_{13}\, z_{15} - z_{14}\, z_{16})$$

$$z_{82} = -m_F(z_{33}\, z_{14} - z_{35}\, z_{12}) - m_{MR}(z_{30}\, z_{14} - z_{32}\, z_{12})$$

$$z_{83} = z_{26}\,(z_{12}^2 + z_{13}^2 + z_{14}^2)$$

$$z_{84} = m_F(z_{34}\, z_{14} - z_{35}\, z_{13}) + m_{MR}(z_{31}\, z_{14} - z_{32}\, z_{13})$$

$$z_{85} = m_F(z_{12}\, z_{42} + z_{13}\, z_{43} + z_{14}\, z_{44}) + m_{MR}(z_{12}\, z_{39} + z_{13}\, z_{40} + z_{14}\, z_{41})$$

$$z_{86} = m_F(z_{33}\, z_{15} + z_{34}\, z_7) + m_{MR}(z_{30}\, z_{15} + z_{31}\, z_7)$$

$$z_{87} = z_{26}\,(z_7^2 + z_{15}^2 + z_{16}^2)$$

$$z_{88} = -m_F(z_{33}\, z_{16} + z_{35}\, z_7) - m_{MR}(z_{30}\, z_{16} + z_{32}\, z_7)$$

$$z_{89} = m_F(z_{34}\, z_{16} - z_{35}\, z_{15}) + m_{MR}(z_{31}\, z_{16} - z_{32}\, z_{15})$$

$$z_{90} = -m_F(z_7\, z_{42} - z_{15}\, z_{43} - z_{16}\, z_{44}) - m_{MR}(z_7\, z_{39} - z_{15}\, z_{40} - z_{16}\, z_{41})$$

$$z_{91} = I_{11}^F + I_{11}^{MR} + m_F(z_{34}^2 + z_{35}^2) + m_{MR}(z_{31}^2 + z_{32}^2)$$

$$z_{92} = -m_F z_{33}\, z_{35} - m_{MR} z_{30}\, z_{32}$$

$$z_{93} = -m_F z_{33}\, z_{34} - m_{MR} z_{30}\, z_{31}$$

$$z_{94} = z_{64} + z_{72} + m_F(z_{34}\, z_{44} - z_{35}\, z_{43}) + m_{MR}(z_{31}\, z_{41} - z_{32}\, z_{40}) - z_{68}$$

$$z_{95} = I_{22}^F + I_{22}^{MR} + m_F(z_{33}^2 + z_{35}^2) + m_{MR}(z_{30}^2 + z_{32}^2)$$

$$z_{96} = -m_F z_{34}\, z_{35} - m_{MR} z_{31}\, z_{32}$$

$$z_{97} = z_{63} + z_{69} + z_{71} - m_F(z_{33}\, z_{44} - z_{35}\, z_{42}) - m_{MR}(z_{30}\, z_{41} - z_{32}\, z_{39})$$

$$z_{98} = I_{33}^F + I_{33}^{MR} + m_F(z_{33}^2 + z_{34}^2) + m_{MR}(z_{30}^2 + z_{31}^2)$$

$$z_{99} = z_{62} + z_{70} + m_F(z_{33}\, z_{43} - z_{34}\, z_{42}) + m_{MR}(z_{30}\, z_{40} - z_{31}\, z_{39})$$

# 3 Dynamic Equations of the Single-Lift Model

The dynamic equations of the single-lift model are presented, which includes both model variants, see the thesis main document [Ber13, pages 55ff.]. The variables $z_{xyz}$ represent intermediate results, which are generated automatically.

## 3.1 First Variant - Frame R Relative to Frame F

For the first model variant, the result of the Kane method is the following set of equations:

$$\begin{aligned}
0 = {} & z_{115} + F_3^{MR} z_{11} + F_2^{TR} z_{10} + z_{141}\,\dot{w} - z_{148} - z_{140}\,\dot{r} \\
& - z_{142}\,\dot{q} - z_{143}\,\dot{u} - z_{144}\,\dot{v} - z_{145}\,\dot{p} - z_{146}\,\dot{q}_r^F - z_{147}\,\dot{p}_r^F
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{116} + F_3^{MR} z_{14} + F_2^{TR} z_{13} + z_{150}\,\dot{w} - z_{156} - z_{144}\,\dot{u} \\
& - z_{149}\,\dot{r} - z_{151}\,\dot{q} - z_{152}\,\dot{v} - z_{153}\,\dot{p} - z_{154}\,\dot{q}_r^F - z_{155}\,\dot{p}_r^F
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{117} + F_3^{MR} z_{16} + F_2^{TR} z_{15} + z_{141}\,\dot{u} + z_{150}\,\dot{v} - z_{163} \\
& - z_{157}\,\dot{r} - z_{158}\,\dot{w} - z_{159}\,\dot{q} - z_{160}\,\dot{p} - z_{161}\,\dot{q}_r^F - z_{162}\,\dot{p}_r^F
\end{aligned}$$

$$\begin{aligned}
0 = {} & T_1^{MR} + z_{31}\,F_3^{MR} + z_{120} + z_{176}\,\dot{q}_r^F + z_{177}\,\dot{p}_r^F - z_{38}\,F_2^{TR} - z_{178} \\
& - z_{145}\,\dot{u} - z_{153}\,\dot{v} - z_{160}\,\dot{w} - z_{167}\,\dot{p} - z_{171}\,\dot{r} - z_{175}\,\dot{q}
\end{aligned}$$

$$\begin{aligned}
0 = {} & T_2^{MR} + T_2^{TR} + z_{122} - z_{30}\,F_3^{MR} - z_{187} - z_{142}\,\dot{u} - z_{151}\,\dot{v} \\
& - z_{159}\,\dot{w} - z_{175}\,\dot{p} - z_{181}\,\dot{q} - z_{184}\,\dot{r} - z_{185}\,\dot{q}_r^F - z_{186}\,\dot{p}_r^F
\end{aligned}$$

$$\begin{aligned}
0 = {} & T_3^{MR} + z_{36}\,F_2^{TR} + z_{123} + z_{191}\,\dot{q}_r^F + z_{192}\,\dot{p}_r^F - z_{193} \\
& - z_{140}\,\dot{u} - z_{149}\,\dot{v} - z_{157}\,\dot{w} - z_{171}\,\dot{p} - z_{184}\,\dot{q} - z_{190}\,\dot{r}
\end{aligned}$$

$$0 = z_{177}\,\dot{p} + z_{192}\,\dot{r} - z_{124} - z_{196} - z_{147}\,\dot{u} - z_{155}\,\dot{v} - z_{162}\,\dot{w} - z_{186}\,\dot{q} - z_{194}\,\dot{q}_r^F - z_{195}\,\dot{p}_r^F$$

$$0 = z_{176}\,\dot{p} + z_{191}\,\dot{r} - z_{125} - z_{198} - z_{146}\,\dot{u} - z_{154}\,\dot{v} - z_{161}\,\dot{w} - z_{185}\,\dot{q} - z_{194}\,\dot{p}_r^F - z_{197}\,\dot{q}_r^F$$

The equations need to be solved for the desired variables ($\dot{u}$, $\dot{v}$, $\dot{w}, \dot{p}$, $\dot{q}$, $\dot{r}$, $\dot{p}_r^F$, $\dot{q}_r^F$) to get the explicit equations.

The following equations define the remaining $z_{xyz}$ variables:

$$z_1 = \pi + \psi$$

$$z_2 = \pi + \theta$$

$$
\begin{aligned}
z_3 &= \cos(z_1) \\
z_4 &= \cos(z_2) \\
z_5 &= z_3\, z_4 \\
z_6 &= \sin(\varphi) \\
z_7 &= \sin(z_2) \\
z_8 &= \cos(\varphi) \\
z_9 &= \sin(z_1) \\
z_{10} &= z_3\, z_6\, z_7 - z_8\, z_9 \\
z_{11} &= z_6\, z_9 + z_3\, z_7\, z_8 \\
z_{12} &= z_4\, z_9 \\
z_{13} &= z_3\, z_8 + z_6\, z_7\, z_9 \\
z_{14} &= z_7\, z_8\, z_9 - z_3\, z_6 \\
z_{15} &= z_4\, z_6 \\
z_{16} &= z_4\, z_8 \\
z_{23} &= \omega_{MR} + r \\
z_{24} &= q\,(r - z_{23}) \\
z_{25} &= p\,(r - z_{23}) \\
z_{26} &= m_F + m_{MR} \\
z_{27} &= (dOFo_1 m_F + dOMRo_1 m_{MR})/z_{26} \\
z_{28} &= (dOFo_2 m_F + dOMRo_2 m_{MR})/z_{26} \\
z_{29} &= (dOFo_3 m_F + dOMRo_3 m_{MR})/z_{26} \\
z_{30} &= dOMRo_1 - z_{27} \\
z_{31} &= dOMRo_2 - z_{28} \\
z_{32} &= dOMRo_3 - z_{29} \\
z_{33} &= dOFo_1 - z_{27} \\
z_{34} &= dOFo_2 - z_{28} \\
z_{35} &= dOFo_3 - z_{29} \\
z_{36} &= dOT_1 - z_{27} \\
z_{38} &= dOT_3 - z_{29} \\
z_{39} &= dORo_1 - z_{27} \\
z_{40} &= dORo_2 - z_{28}
\end{aligned}
$$

$$z_{41} = dORo_3 - z_{29}$$
$$z_{42} = -q\,(z_{30}\,q\, - z_{31}\,p\,) - r\,(z_{30}\,r\, - z_{32}\,p\,)$$
$$z_{43} = p\,(z_{30}\,q\, - z_{31}\,p\,) - r\,(z_{31}\,r\, - z_{32}\,q\,)$$
$$z_{44} = p\,(z_{30}\,r\, - z_{32}\,p\,) + q\,(z_{31}\,r\, - z_{32}\,q\,)$$
$$z_{45} = -q\,(z_{33}\,q\, - z_{34}\,p\,) - r\,(z_{33}\,r\, - z_{35}\,p\,)$$
$$z_{46} = p\,(z_{33}\,q\, - z_{34}\,p\,) - r\,(z_{34}\,r\, - z_{35}\,q\,)$$
$$z_{47} = p\,(z_{33}\,r\, - z_{35}\,p\,) + q\,(z_{34}\,r\, - z_{35}\,q\,)$$
$$z_{54} = \cos(\theta_r^F)$$
$$z_{55} = \sin(\varphi_r^F)$$
$$z_{56} = \sin(\theta_r^F)$$
$$z_{57} = z_{55}\,z_{56}$$
$$z_{58} = \cos(\varphi_r^F)$$
$$z_{59} = z_{56}\,z_{58}$$
$$z_{60} = z_{54}\,z_{55}$$
$$z_{61} = z_{54}\,z_{58}$$
$$z_{62} = z_{59}\,z_{60}\, - z_{57}\,z_{61}$$
$$z_{63} = z_{55}^2 + z_{59}^2 + z_{61}^2$$
$$z_{64} = z_{54}\,z_{61}\, + z_{56}\,z_{59}$$
$$z_{65} = z_{56}\,z_{60}\, - z_{54}\,z_{57}$$
$$z_{66} = -z_{54}\,z_{60}\, - z_{56}\,z_{57}$$
$$z_{67} = z_5\,z_{54}\, - z_{11}\,z_{56}$$
$$z_{68} = z_{12}\,z_{54}\, - z_{14}\,z_{56}$$
$$z_{69} = -z_7\,z_{54}\, - z_{16}\,z_{56}$$
$$z_{70} = z_5\,z_{57}\, + z_{10}\,z_{58}\, + z_{11}\,z_{60}$$
$$z_{71} = z_{12}\,z_{57}\, + z_{13}\,z_{58}\, + z_{14}\,z_{60}$$
$$z_{72} = z_{15}\,z_{58}\, + z_{16}\,z_{60}\, - z_7\,z_{57}$$
$$z_{73} = z_5\,z_{59}\, + z_{11}\,z_{61}\, - z_{10}\,z_{55}$$
$$z_{74} = z_{12}\,z_{59}\, + z_{14}\,z_{61}\, - z_{13}\,z_{55}$$
$$z_{75} = z_{16}\,z_{61}\, - z_7\,z_{59}\, - z_{15}\,z_{55}$$
$$z_{76} = l_{rp}\,z_{57}$$
$$z_{77} = l_{rp}\,z_{58}$$

$$z_{78} = l_{\mathcal{P}}\, z_{60}$$

$$z_{79} = l_{\mathcal{P}}\, z_{64}$$

$$z_{80} = l_{\mathcal{P}}\, z_{65}$$

$$z_{81} = l_{\mathcal{P}}\, z_{56}$$

$$z_{82} = l_{\mathcal{P}}\, z_{54}$$

$$z_{83} = l_{\mathcal{P}}\, z_{62}$$

$$z_{84} = l_{\mathcal{P}}\, z_{63}$$

$$z_{85} = z_{41}\, q \; - z_{40}\, r$$

$$z_{86} = z_{39}\, r \; - z_{41}\, p$$

$$z_{87} = z_{40}\, p \; - z_{39}\, q$$

$$z_{88} = z_{76}\, p \; + z_{77}\, q \; + z_{78}\, r \; + z_{79}\, q_r^F \; + z_{80}\, p_r^F$$

$$z_{89} = z_{81}\, r \; - z_{82}\, p \; - z_{83}\, q_r^F \; - z_{84}\, p_r^F$$

$$z_{90} = z_{54}\, z_{55}\, q_r^F \; + z_{56}\, z_{58}\, p_r^F$$

$$z_{91} = l_{\mathcal{P}}\, z_{55}\, p_r^F$$

$$z_{92} = z_{54}\, z_{58}\, p_r^F \; - z_{55}\, z_{56}\, q_r^F$$

$$z_{93} = -z_{54}\, z_{55}\, p_r^F \; - z_{56}\, z_{58}\, q_r^F$$

$$z_{94} = z_{54}\, z_{58}\, q_r^F \; - z_{55}\, z_{56}\, p_r^F$$

$$z_{95} = z_{54}\, z_{59}\, q_r^F \; + z_{54}\, z_{93} \; + z_{56}\, z_{94} \; - z_{56}\, z_{61}\, q_r^F$$

$$z_{96} = z_{54}\, z_{60}\, q_r^F \; + z_{56}\, z_{57}\, q_r^F \; + z_{56}\, z_{92} \; - z_{54}\, z_{90}$$

$$z_{97} = l_{\mathcal{P}}\, p\, z_{90} \; + l_{\mathcal{P}}\, r\, z_{92} \; + l_{\mathcal{P}}\, p_r^F \; z_{96} \; + l_{\mathcal{P}}\, q_r^F \; z_{95} \; - q\, z_{91}$$

$$z_{98} = z_{54}\, p \; + z_{62}\, q_r^F \; + z_{63}\, p_r^F \; - z_{56}\, r$$

$$z_{99} = z_{57}\, p \; + z_{58}\, q \; + z_{60}\, r \; + z_{64}\, q_r^F \; + z_{65}\, p_r^F$$

$$z_{100} = z_{59}\, p \; + z_{61}\, r \; + z_{66}\, q_r^F \; - z_{55}\, q$$

$$z_{101} = l_{\mathcal{P}}\, z_{54}\, q_r^F$$

$$z_{102} = l_{\mathcal{P}}\, z_{56}\, q_r^F$$

$$z_{103} = z_{59}\, z_{92} \; + z_{60}\, z_{94} \; - z_{57}\, z_{93} \; - z_{61}\, z_{90}$$

$$z_{104} = 2z_{55}\, z_{58}\, p_r^F \; + 2z_{59}\, z_{94} \; + 2z_{61}\, z_{93}$$

$$z_{105} = p\,z_{102} + r\,z_{101} - l_{rp}\,p_r^F\,z_{104} - l_{rp}\,q_r^F\,z_{103}$$

$$z_{106} = q\,z_{87} - r\,z_{86}$$

$$z_{107} = r\,z_{85} - p\,z_{87}$$

$$z_{108} = p\,z_{86} - q\,z_{85}$$

$$z_{109} = z_{97} - z_{89}\,z_{100}$$

$$z_{110} = z_{105} + z_{88}\,z_{100}$$

$$z_{111} = z_{89}\,z_{98} - z_{88}\,z_{99}$$

$$z_{112} = g\,m_F$$

$$z_{113} = g\,l_{rp}$$

$$z_{114} = g\,m_{MR}$$

$$z_{115} = z_{114}\,z_5\,z_7 + z_{112}\,(z_5\,z_7 - z_{10}\,z_{15} - z_{11}\,z_{16}) - z_{114}\,z_{10}\,z_{15} - z_{114}\,z_{11}\,z_{16}$$

$$z_{116} = z_{114}\,z_7\,z_{12} + z_{112}\,(z_7\,z_{12} - z_{13}\,z_{15} - z_{14}\,z_{16}) - z_{114}\,z_{13}\,z_{15} - z_{114}\,z_{14}\,z_{16}$$

$$z_{117} = -z_{113} - z_{114}\,z_7^2 - z_{114}\,z_{15}^2 - z_{114}\,z_{16}^2 - z_{112}\,(z_7^2 + z_{15}^2 + z_{16}^2)$$

$$z_{118} = z_{32}\,z_{114}$$

$$z_{119} = z_{31}\,z_{114}$$

$$\begin{aligned} z_{120} = {} & z_{118}\,z_{15} - z_{119}\,z_{16} - z_{112}\,(z_{34}\,z_{16} - z_{35}\,z_{15}) \\ & - z_{113}\,(z_{40}\,z_{16} + z_{69}\,z_{76} - z_{41}\,z_{15} - z_{72}\,z_{82}) \end{aligned}$$

$$z_{121} = z_{30}\,z_{114}$$

$$z_{122} = z_{118}\,z_7 + z_{121}\,z_{16} + z_{112}\,(z_{33}\,z_{16} + z_{35}\,z_7) + z_{113}\,(z_{39}\,z_{16} + z_{41}\,z_7 - z_{69}\,z_{77})$$

$$\begin{aligned} z_{123} = {} & -z_{112}\,(z_{33}\,z_{15} + z_{34}\,z_7) - z_{114}\,(z_{30}\,z_{15} + z_{31}\,z_7) \\ & - z_{113}\,(z_{39}\,z_{15} + z_{40}\,z_7 + z_{69}\,z_{78} + z_{72}\,z_{81}) \end{aligned}$$

$$z_{124} = z_{113}\,(z_{69}\,z_{80} - z_{72}\,z_{84})$$

$$z_{125} = z_{113}\,(z_{69}\,z_{79} - z_{72}\,z_{83})$$

$$z_{126} = I_{11}^F\,p$$

$$z_{127} = I_{22}^F\,q$$

$$z_{128} = I_{33}^F\,r$$

$$z_{129} = p\,z_{127} - q\,z_{126}$$

$$z_{130} = r\,z_{126} - p\,z_{128}$$

$$z_{131} = q\,z_{128} - r\,z_{127}$$

$$z_{132} = I_{11}^{MR}\,p$$

$$z_{133} = I_{22}^{MR}\,q$$

$$z_{134} = I_{33}^{MR}\, z_{23}$$

$$z_{135} = I_{11}^{MR}\, z_{24}$$

$$z_{136} = I_{22}^{MR}\, z_{25}$$

$$z_{137} = p\, z_{133} - q\, z_{132}$$

$$z_{138} = z_{23}\, z_{132} - p\, z_{134}$$

$$z_{139} = q\, z_{134} - z_{23}\, z_{133}$$

$$\begin{aligned} z_{140} &= m_F\,(z_{33}\, z_{10} - z_{34}\, z_5\,) + m_{MR}\,(z_{30}\, z_{10} - z_{31}\, z_5\,) \\ &\quad - l_{\mathcal{P}}\,(z_{40}\, z_5 - z_{39}\, z_{10} - z_{67}\, z_{78} - z_{70}\, z_{81}\,) \end{aligned}$$

$$z_{141} = z_{26}\,(z_5\, z_7 - z_{10}\, z_{15} - z_{11}\, z_{16}\,)$$

$$z_{142} = -m_F\,(z_{33}\, z_{11} - z_{35}\, z_5\,) - m_{MR}\,(z_{30}\, z_{11} - z_{32}\, z_5\,) - l_{\mathcal{P}}\,(z_{39}\, z_{11} - z_{41}\, z_5 - z_{67}\, z_{77}\,)$$

$$z_{143} = l_{\mathcal{P}} + m_F\,(z_5^2 + z_{10}^2 + z_{11}^2) + m_{MR}\,(z_5^2 + z_{10}^2 + z_{11}^2)$$

$$z_{144} = z_{26}\,(z_5\, z_{12} + z_{10}\, z_{13} + z_{11}\, z_{14}\,)$$

$$\begin{aligned} z_{145} &= m_F\,(z_{34}\, z_{11} - z_{35}\, z_{10}\,) + m_{MR}\,(z_{31}\, z_{11} - z_{32}\, z_{10}\,) \\ &\quad + l_{\mathcal{P}}\,(z_{40}\, z_{11} + z_{67}\, z_{76} - z_{41}\, z_{10} - z_{70}\, z_{82}\,) \end{aligned}$$

$$z_{146} = l_{\mathcal{P}}\,(z_{67}\, z_{79} - z_{70}\, z_{83}\,)$$

$$z_{147} = l_{\mathcal{P}}\,(z_{67}\, z_{80} - z_{70}\, z_{84}\,)$$

$$\begin{aligned} z_{148} &= m_F\,(z_5\, z_{45} + z_{10}\, z_{46} + z_{11}\, z_{47}\,) + m_{MR}\,(z_5\, z_{42} + z_{10}\, z_{43} + z_{11}\, z_{44}\,) \\ &\quad + l_{\mathcal{P}}\,(z_5\, z_{106} + z_{10}\, z_{107} + z_{11}\, z_{108} + z_{67}\, z_{109} + z_{70}\, z_{110} + z_{73}\, z_{111}\,) \end{aligned}$$

$$\begin{aligned} z_{149} &= m_F\,(z_{33}\, z_{13} - z_{34}\, z_{12}\,) + m_{MR}\,(z_{30}\, z_{13} - z_{31}\, z_{12}\,) \\ &\quad - l_{\mathcal{P}}\,(z_{40}\, z_{12} - z_{39}\, z_{13} - z_{68}\, z_{78} - z_{71}\, z_{81}\,) \end{aligned}$$

$$z_{150} = z_{26}\,(z_7\, z_{12} - z_{13}\, z_{15} - z_{14}\, z_{16}\,)$$

$$z_{151} = -m_F\,(z_{33}\, z_{14} - z_{35}\, z_{12}\,) - m_{MR}\,(z_{30}\, z_{14} - z_{32}\, z_{12}\,) - l_{\mathcal{P}}\,(z_{39}\, z_{14} - z_{41}\, z_{12} - z_{68}\, z_{77}\,)$$

$$z_{152} = l_{\mathcal{P}} + m_F\,(z_{12}^2 + z_{13}^2 + z_{14}^2) + m_{MR}\,(z_{12}^2 + z_{13}^2 + z_{14}^2)$$

$$\begin{aligned} z_{153} &= m_F\,(z_{34}\, z_{14} - z_{35}\, z_{13}\,) + m_{MR}\,(z_{31}\, z_{14} - z_{32}\, z_{13}\,) \\ &\quad + l_{\mathcal{P}}\,(z_{40}\, z_{14} + z_{68}\, z_{76} - z_{41}\, z_{13} - z_{71}\, z_{82}\,) \end{aligned}$$

$$z_{154} = l_{\mathcal{P}}\,(z_{68}\, z_{79} - z_{71}\, z_{83}\,)$$

$$z_{155} = l_{\mathcal{P}}\,(z_{68}\, z_{80} - z_{71}\, z_{84}\,)$$

$$\begin{aligned} z_{156} &= m_F\,(z_{12}\, z_{45} + z_{13}\, z_{46} + z_{14}\, z_{47}\,) + m_{MR}\,(z_{12}\, z_{42} + z_{13}\, z_{43} + z_{14}\, z_{44}\,) \\ &\quad + l_{\mathcal{P}}\,(z_{12}\, z_{106} + z_{13}\, z_{107} + z_{14}\, z_{108} + z_{68}\, z_{109} + z_{71}\, z_{110} + z_{74}\, z_{111}\,) \end{aligned}$$

$$\begin{aligned} z_{157} &= m_F\,(z_{33}\, z_{15} + z_{34}\, z_7\,) + m_{MR}\,(z_{30}\, z_{15} + z_{31}\, z_7\,) \\ &\quad + l_{\mathcal{P}}\,(z_{39}\, z_{15} + z_{40}\, z_7 + z_{69}\, z_{78} + z_{72}\, z_{81}\,) \end{aligned}$$

$$z_{158} = l_{\mathcal{P}} + m_F\,(z_7^2 + z_{15}^2 + z_{16}^2) + m_{MR}\,(z_7^2 + z_{15}^2 + z_{16}^2)$$

$$z_{159} = -m_F\,(z_{33}\,z_{16} + z_{35}\,z_7) - m_{MR}\,(z_{30}\,z_{16} + z_{32}\,z_7) - l_{\mathcal{P}}\,(z_{39}\,z_{16} + z_{41}\,z_7 - z_{69}\,z_{77})$$

$$\begin{aligned} z_{160} = {} & m_F\,(z_{34}\,z_{16} - z_{35}\,z_{15}) + m_{MR}\,(z_{31}\,z_{16} - z_{32}\,z_{15}) \\ & + l_{\mathcal{P}}\,(z_{40}\,z_{16} + z_{69}\,z_{76} - z_{41}\,z_{15} - z_{72}\,z_{82}) \end{aligned}$$

$$z_{161} = l_{\mathcal{P}}\,(z_{69}\,z_{79} - z_{72}\,z_{83})$$

$$z_{162} = l_{\mathcal{P}}\,(z_{69}\,z_{80} - z_{72}\,z_{84})$$

$$\begin{aligned} z_{163} = {} & -m_F\,(z_7\,z_{45} - z_{15}\,z_{46} - z_{16}\,z_{47}) - m_{MR}\,(z_7\,z_{42} - z_{15}\,z_{43} - z_{16}\,z_{44}) \\ & - l_{\mathcal{P}}\,(z_7\,z_{106} - z_{15}\,z_{107} - z_{16}\,z_{108} - z_{69}\,z_{109} - z_{72}\,z_{110} - z_{75}\,z_{111}) \end{aligned}$$

$$z_{164} = I_{11}^F + I_{11}^{MR} + m_F\,(z_{34}^2 + z_{35}^2) + m_{MR}\,(z_{31}^2 + z_{32}^2)$$

$$z_{165} = z_{40}^2$$

$$z_{166} = z_{41}^2$$

$$z_{167} = z_{164} - l_{\mathcal{P}}\,(2z_{40}\,z_{56}\,z_{76} + 2z_{40}\,z_{60}\,z_{82} - z_{165} - z_{166} - z_{76}^2 - z_{82}^2 - 2z_{41}\,z_{58}\,z_{82})$$

$$z_{168} = m_F\,z_{33}\,z_{35}$$

$$z_{169} = m_{MR}\,z_{30}\,z_{32}$$

$$z_{170} = z_{39}\,z_{41}$$

$$\begin{aligned} z_{171} = {} & l_{\mathcal{P}}\,(z_{76}\,z_{78} + z_{40}\,z_{57}\,z_{82} + z_{40}\,z_{60}\,z_{81} - z_{170} - z_{81}\,z_{82} - z_{39}\,z_{58}\,z_{82} - z_{40}\,z_{54}\,z_{76} \\ & - z_{40}\,z_{56}\,z_{78} - z_{41}\,z_{58}\,z_{81}) - z_{168} - z_{169} \end{aligned}$$

$$z_{172} = m_F\,z_{33}\,z_{34}$$

$$z_{173} = m_{MR}\,z_{30}\,z_{31}$$

$$z_{174} = z_{39}\,z_{40}$$

$$\begin{aligned} z_{175} = {} & l_{\mathcal{P}}\,(z_{76}\,z_{77} + z_{39}\,z_{56}\,z_{76} + z_{39}\,z_{60}\,z_{82} + z_{41}\,z_{54}\,z_{76} - z_{174} - z_{40}\,z_{56}\,z_{77} - z_{41}\,z_{57}\,z_{82}) \\ & - z_{172} - z_{173} \end{aligned}$$

$$z_{176} = l_{\mathcal{P}}\,(z_{40}\,z_{56}\,z_{79} + z_{40}\,z_{60}\,z_{83} - z_{76}\,z_{79} - z_{82}\,z_{83} - z_{41}\,z_{58}\,z_{83})$$

$$z_{177} = l_{\mathcal{P}}\,(z_{40}\,z_{56}\,z_{80} + z_{40}\,z_{60}\,z_{84} - z_{76}\,z_{80} - z_{82}\,z_{84} - z_{41}\,z_{58}\,z_{84})$$

$$\begin{aligned} z_{178} = {} & z_{131} + z_{139} + m_F\,(z_{34}\,z_{47} - z_{35}\,z_{46}) + m_{MR}\,(z_{31}\,z_{44} - z_{32}\,z_{43}) \\ & + l_{\mathcal{P}}\,(z_{40}\,z_{108} + z_{76}\,z_{109} + z_{40}\,z_{60}\,z_{110} + z_{40}\,z_{61}\,z_{111} + z_{41}\,z_{55}\,z_{111} + z_{54}\,z_{76}\,z_{106} \\ & - z_{41}\,z_{107} - z_{82}\,z_{110} - z_{40}\,z_{56}\,z_{109} - z_{41}\,z_{58}\,z_{110} - z_{56}\,z_{76}\,z_{108} - z_{57}\,z_{82}\,z_{106} \\ & - z_{58}\,z_{82}\,z_{107} - z_{60}\,z_{82}\,z_{108}) - z_{135} \end{aligned}$$

$$z_{179} = I_{22}^F + I_{22}^{MR} + m_F\,(z_{33}^2 + z_{35}^2) + m_{MR}\,(z_{30}^2 + z_{32}^2)$$

$$z_{180} = z_{39}^2 + z_{41}^2$$

$$z_{181} = z_{179} + l_{\mathcal{P}}\,(z_{180} + z_{77}^2 + 2z_{39}\,z_{56}\,z_{77} + 2z_{41}\,z_{54}\,z_{77})$$

$$z_{182} = -m_F\, z_{34}\, z_{35} - m_{MR}\, z_{31}\, z_{32}$$

$$z_{183} = z_{40}\, z_{41}$$

$$\begin{aligned} z_{184} &= z_{182} \\ &\quad - l_{\mathcal{P}}\,(z_{183} + z_{39}\, z_{60}\, z_{81} + z_{40}\, z_{54}\, z_{77} - z_{77}\, z_{78} - z_{39}\, z_{56}\, z_{78} - z_{41}\, z_{54}\, z_{78} - z_{41}\, z_{57}\, z_{81}\,) \end{aligned}$$

$$z_{185} = l_{\mathcal{P}}\,(z_{77}\, z_{79} + z_{39}\, z_{56}\, z_{79} + z_{39}\, z_{60}\, z_{83} + z_{41}\, z_{54}\, z_{79} - z_{41}\, z_{57}\, z_{83}\,)$$

$$z_{186} = l_{\mathcal{P}}\,(z_{77}\, z_{80} + z_{39}\, z_{56}\, z_{80} + z_{39}\, z_{60}\, z_{84} + z_{41}\, z_{54}\, z_{80} - z_{41}\, z_{57}\, z_{84}\,)$$

$$\begin{aligned} z_{187} &= z_{130} + z_{136} + z_{138} + l_{\mathcal{P}}\,(z_{41}\, z_{106} + z_{77}\, z_{109} + z_{39}\, z_{56}\, z_{109} + z_{41}\, z_{54}\, z_{109} + z_{41}\, z_{57}\, z_{110} \\ &\quad + z_{41}\, z_{59}\, z_{111} + z_{54}\, z_{77}\, z_{106} - z_{39}\, z_{108} - z_{39}\, z_{60}\, z_{110} - z_{39}\, z_{61}\, z_{111} - z_{56}\, z_{77}\, z_{108}\,) \\ &\quad - m_F\,(z_{33}\, z_{47} - z_{35}\, z_{45}\,) - m_{MR}\,(z_{30}\, z_{44} - z_{32}\, z_{42}\,) \end{aligned}$$

$$z_{188} = I_{33}^F + I_{33}^{MR} + m_F\,(z_{33}^2 + z_{34}^2) + m_{MR}\,(z_{30}^2 + z_{31}^2)$$

$$z_{189} = z_{39}^2 + z_{40}^2$$

$$z_{190} = z_{188} + l_{\mathcal{P}}\,(z_{189} + z_{78}^2 + z_{81}^2 + 2z_{39}\, z_{58}\, z_{81} - 2z_{40}\, z_{54}\, z_{78} - 2z_{40}\, z_{57}\, z_{81}\,)$$

$$z_{191} = l_{\mathcal{P}}\,(z_{81}\, z_{83} + z_{39}\, z_{58}\, z_{83} + z_{40}\, z_{54}\, z_{79} - z_{78}\, z_{79} - z_{40}\, z_{57}\, z_{83}\,)$$

$$z_{192} = l_{\mathcal{P}}\,(z_{81}\, z_{84} + z_{39}\, z_{58}\, z_{84} + z_{40}\, z_{54}\, z_{80} - z_{78}\, z_{80} - z_{40}\, z_{57}\, z_{84}\,)$$

$$\begin{aligned} z_{193} &= z_{129} + z_{137} + m_F\,(z_{33}\, z_{46} - z_{34}\, z_{45}\,) + m_{MR}\,(z_{30}\, z_{43} - z_{31}\, z_{42}\,) \\ &\quad - l_{\mathcal{P}}\,(z_{40}\, z_{106} + z_{39}\, z_{55}\, z_{111} + z_{40}\, z_{54}\, z_{109} + z_{40}\, z_{57}\, z_{110} + z_{40}\, z_{59}\, z_{111} \\ &\qquad + z_{56}\, z_{78}\, z_{108} - z_{39}\, z_{107} - z_{78}\, z_{109} - z_{81}\, z_{110} - z_{39}\, z_{58}\, z_{110} - z_{54}\, z_{78}\, z_{106} \\ &\qquad - z_{57}\, z_{81}\, z_{106} - z_{58}\, z_{81}\, z_{107} - z_{60}\, z_{81}\, z_{108}\,) \end{aligned}$$

$$z_{194} = l_{\mathcal{P}}\,(z_{79}\, z_{80} + z_{83}\, z_{84}\,)$$

$$z_{195} = l_{\mathcal{P}}\,(z_{80}^2 + z_{84}^2)$$

$$\begin{aligned} z_{196} &= l_{\mathcal{P}}\,(z_{80}\, z_{109} + z_{54}\, z_{80}\, z_{106} - z_{84}\, z_{110} - z_{56}\, z_{80}\, z_{108} - z_{57}\, z_{84}\, z_{106} - z_{58}\, z_{84}\, z_{107} \\ &\quad - z_{60}\, z_{84}\, z_{108}\,) \end{aligned}$$

$$z_{197} = l_{\mathcal{P}}\,(z_{79}^2 + z_{83}^2)$$

$$\begin{aligned} z_{198} &= l_{\mathcal{P}}\,(z_{79}\, z_{109} + z_{54}\, z_{79}\, z_{106} - z_{83}\, z_{110} - z_{56}\, z_{79}\, z_{108} - z_{57}\, z_{83}\, z_{106} - z_{58}\, z_{83}\, z_{107} \\ &\quad - z_{60}\, z_{83}\, z_{108}\,) \end{aligned}$$

## 3.2 Second Variant - Frame R Relative to Frame N

For the second model variant, the result of the Kane method is the following set of equations:

$$\begin{aligned} 0 &= z_{99} + F_3^{MR} z_{11} + F_2^{TR} z_{10} + z_{134}\,\dot{w} + z_{139}\,\dot{q}_r^N + z_{140}\,\dot{p}_r^N \\ &\quad - z_{141} - z_{133}\,\dot{r} - z_{135}\,\dot{q} - z_{136}\,\dot{u} - z_{137}\,\dot{v} - z_{138}\,\dot{p} \end{aligned}$$

$$
\begin{aligned}
0 &= z_{100} + F_3^{MR} z_{14} + F_2^{TR} z_{13} + z_{143}\,\dot{w} - z_{149} - z_{137}\,\dot{u} \\
&\quad - z_{142}\,\dot{r} - z_{144}\,\dot{q} - z_{145}\,\dot{v} - z_{146}\,\dot{p} - z_{147}\,\dot{q}_r^N - z_{148}\,\dot{p}_r^N \\
0 &= z_{101} + F_3^{MR} z_{16} + F_2^{TR} z_{15} + z_{134}\,\dot{u} + z_{143}\,\dot{v} + z_{154}\,\dot{q}_r^N \\
&\quad + z_{155}\,\dot{p}_r^N - z_{156} - z_{150}\,\dot{r} - z_{151}\,\dot{w} - z_{152}\,\dot{q} - z_{153}\,\dot{p} \\
0 &= T_1^{MR} + z_{31}\,F_3^{MR} + z_{104} + z_{160}\,\dot{q}_r^N + z_{161}\,\dot{p}_r^N - z_{38}\,F_2^{TR} \\
&\quad - z_{162} - z_{157}\,\dot{p} - z_{158}\,\dot{r} - z_{159}\,\dot{q} - z_{138}\,\dot{u} - z_{146}\,\dot{v} - z_{153}\,\dot{w} \\
0 &= T_2^{MR} + T_2^{TR} + z_{106} - z_{30}\,F_3^{MR} - z_{167} - z_{159}\,\dot{p} - z_{163}\,\dot{q} \\
&\quad - z_{164}\,\dot{r} - z_{135}\,\dot{u} - z_{144}\,\dot{v} - z_{152}\,\dot{w} - z_{165}\,\dot{q}_r^N - z_{166}\,\dot{p}_r^N \\
0 &= T_3^{MR} + z_{36}\,F_2^{TR} + z_{107} + z_{169}\,\dot{q}_r^N + z_{170}\,\dot{p}_r^N - z_{171} \\
&\quad - z_{158}\,\dot{p} - z_{164}\,\dot{q} - z_{168}\,\dot{r} - z_{133}\,\dot{u} - z_{142}\,\dot{v} - z_{150}\,\dot{w} \\
0 &= z_{108} + z_{140}\,\dot{u} + z_{155}\,\dot{w} + z_{161}\,\dot{p} + z_{170}\,\dot{r} - z_{174} - z_{148}\,\dot{v} - z_{166}\,\dot{q} - z_{172}\,\dot{q}_r^N - z_{173}\,\dot{p}_r^N \\
0 &= z_{109} + z_{139}\,\dot{u} + z_{154}\,\dot{w} + z_{160}\,\dot{p} + z_{169}\,\dot{r} - z_{176} - z_{147}\,\dot{v} - z_{165}\,\dot{q} - z_{172}\,\dot{p}_r^N - z_{175}\,\dot{q}_r^N
\end{aligned}
$$

The equations need to be solved for the desired variables ($\dot{u}$, $\dot{v}$, $\dot{w}$,$\dot{p}$, $\dot{q}$, $\dot{r}$, $\dot{p}_r^N$, $\dot{q}_r^N$) to get the explicit equations.

The following equations define the remaining $z_{xyz}$ variables:

$$
\begin{aligned}
z_1 &= \pi + \psi \\
z_2 &= \pi + \theta \\
z_3 &= \cos(z_1) \\
z_4 &= \cos(z_2) \\
z_5 &= z_3\,z_4 \\
z_6 &= \sin(\varphi) \\
z_7 &= \sin(z_2) \\
z_8 &= \cos(\varphi) \\
z_9 &= \sin(z_1) \\
z_{10} &= z_3\,z_6\,z_7 - z_8\,z_9 \\
z_{11} &= z_6\,z_9 + z_3\,z_7\,z_8 \\
z_{12} &= z_4\,z_9 \\
z_{13} &= z_3\,z_8 + z_6\,z_7\,z_9 \\
z_{14} &= z_7\,z_8\,z_9 - z_3\,z_6 \\
z_{15} &= z_4\,z_6 \\
z_{16} &= z_4\,z_8
\end{aligned}
$$

$$
\begin{aligned}
z_{23} &= \omega_{MR} + r \\
z_{24} &= q\,(r - z_{23}\,) \\
z_{25} &= p\,(r - z_{23}\,) \\
z_{26} &= m_F + m_{MR} \\
z_{27} &= (dOFo_1 m_F + dOMRo_1 m_{MR}\,)/z_{26} \\
z_{28} &= (dOFo_2 m_F + dOMRo_2 m_{MR}\,)/z_{26} \\
z_{29} &= (dOFo_3 m_F + dOMRo_3 m_{MR}\,)/z_{26} \\
z_{30} &= dOMRo_1 - z_{27} \\
z_{31} &= dOMRo_2 - z_{28} \\
z_{32} &= dOMRo_3 - z_{29} \\
z_{33} &= dOFo_1 - z_{27} \\
z_{34} &= dOFo_2 - z_{28} \\
z_{35} &= dOFo_3 - z_{29} \\
z_{36} &= dOT_1 - z_{27} \\
z_{38} &= dOT_3 - z_{29} \\
z_{39} &= dORo_1 - z_{27} \\
z_{40} &= dORo_2 - z_{28} \\
z_{41} &= dORo_3 - z_{29} \\
z_{42} &= -q\,(z_{30}\,q - z_{31}\,p\,) - r\,(z_{30}\,r - z_{32}\,p\,) \\
z_{43} &= p\,(z_{30}\,q - z_{31}\,p\,) - r\,(z_{31}\,r - z_{32}\,q\,) \\
z_{44} &= p\,(z_{30}\,r - z_{32}\,p\,) + q\,(z_{31}\,r - z_{32}\,q\,) \\
z_{45} &= -q\,(z_{33}\,q - z_{34}\,p\,) - r\,(z_{33}\,r - z_{35}\,p\,) \\
z_{46} &= p\,(z_{33}\,q - z_{34}\,p\,) - r\,(z_{34}\,r - z_{35}\,q\,) \\
z_{47} &= p\,(z_{33}\,r - z_{35}\,p\,) + q\,(z_{34}\,r - z_{35}\,q\,) \\
z_{54} &= \pi + \theta_r^N \\
z_{55} &= \cos(z_{54}\,) \\
z_{56} &= \sin(\varphi_r^N) \\
z_{57} &= \sin(z_{54}\,) \\
z_{58} &= z_{56}\,z_{57} \\
z_{59} &= \cos(\varphi_r^N)
\end{aligned}
$$

$$
\begin{aligned}
z_{60} &= z_{57}\, z_{59} \\
z_{61} &= z_{55}\, z_{56} \\
z_{62} &= z_{55}\, z_{59} \\
z_{63} &= z_{60}\, z_{61} - z_{58}\, z_{62} \\
z_{64} &= z_{56}^2 + z_{60}^2 + z_{62}^2 \\
z_{65} &= z_{55}\, z_{62} + z_{57}\, z_{60} \\
z_{66} &= z_{57}\, z_{61} - z_{55}\, z_{58} \\
z_{67} &= -z_{55}\, z_{61} - z_{57}\, z_{58} \\
z_{68} &= l_{rp}\, z_{65} \\
z_{69} &= l_{rp}\, z_{66} \\
z_{70} &= l_{rp}\, z_{63} \\
z_{71} &= l_{rp}\, z_{64} \\
z_{72} &= z_{41}\, q - z_{40}\, r \\
z_{73} &= z_{39}\, r - z_{41}\, p \\
z_{74} &= z_{40}\, p - z_{39}\, q \\
z_{75} &= z_{68}\, q_r^N + z_{69}\, p_r^N \\
z_{76} &= -z_{70}\, q_r^N - z_{71}\, p_r^N \\
z_{77} &= -z_{55}\, z_{56}\, p_r^N - z_{57}\, z_{59}\, q_r^N \\
z_{78} &= z_{55}\, z_{59}\, q_r^N - z_{56}\, z_{57}\, p_r^N \\
z_{79} &= z_{55}\, z_{60}\, q_r^N + z_{55}\, z_{77} + z_{57}\, z_{78} - z_{57}\, z_{62}\, q_r^N \\
z_{80} &= z_{55}\, z_{59}\, p_r^N - z_{56}\, z_{57}\, q_r^N \\
z_{81} &= z_{55}\, z_{56}\, q_r^N + z_{57}\, z_{59}\, p_r^N \\
z_{82} &= z_{55}\, z_{61}\, q_r^N + z_{57}\, z_{58}\, q_r^N + z_{57}\, z_{80} - z_{55}\, z_{81} \\
z_{83} &= l_{rp}\, (p_r^N\, z_{82} + q_r^N\, z_{79}\,) \\
z_{84} &= z_{63}\, q_r^N + z_{64}\, p_r^N \\
z_{85} &= z_{65}\, q_r^N + z_{66}\, p_r^N \\
z_{86} &= z_{67}\, q_r^N \\
z_{87} &= z_{60}\, z_{80} + z_{61}\, z_{78} - z_{58}\, z_{77} - z_{62}\, z_{81} \\
z_{88} &= 2z_{56}\, z_{59}\, p_r^N + 2z_{60}\, z_{78} + 2z_{62}\, z_{77}
\end{aligned}
$$

$$z_{89} = l_{rp}\,(p_r^N\,z_{88} + q_r^N\,z_{87})$$
$$z_{90} = q\,z_{74} - r\,z_{73}$$
$$z_{91} = r\,z_{72} - p\,z_{74}$$
$$z_{92} = p\,z_{73} - q\,z_{72}$$
$$z_{93} = z_{83} - z_{76}\,z_{86}$$
$$z_{94} = z_{75}\,z_{86} - z_{89}$$
$$z_{95} = z_{76}\,z_{84} - z_{75}\,z_{85}$$
$$z_{96} = g\,m_F$$
$$z_{97} = g\,l_{rp}$$
$$z_{98} = g\,m_{MR}$$
$$z_{99} = z_{98}\,z_5\,z_7 + z_{96}\,(z_5\,z_7 - z_{10}\,z_{15} - z_{11}\,z_{16}) - z_{98}\,z_{10}\,z_{15} - z_{98}\,z_{11}\,z_{16}$$
$$z_{100} = z_{98}\,z_7\,z_{12} + z_{96}\,(z_7\,z_{12} - z_{13}\,z_{15} - z_{14}\,z_{16}) - z_{98}\,z_{13}\,z_{15} - z_{98}\,z_{14}\,z_{16}$$
$$z_{101} = -z_{97} - z_{98}\,z_7^2 - z_{98}\,z_{15}^2 - z_{98}\,z_{16}^2 - z_{96}\,(z_7^2 + z_{15}^2 + z_{16}^2)$$
$$z_{102} = z_{32}\,z_{98}$$
$$z_{103} = z_{31}\,z_{98}$$
$$z_{104} = z_{102}\,z_{15} - z_{103}\,z_{16} - z_{96}\,(z_{34}\,z_{16} - z_{35}\,z_{15}) - z_{97}\,(z_{40}\,z_{16} - z_{41}\,z_{15})$$
$$z_{105} = z_{30}\,z_{98}$$
$$z_{106} = z_{102}\,z_7 + z_{105}\,z_{16} + z_{96}\,(z_{33}\,z_{16} + z_{35}\,z_7) + z_{97}\,(z_{39}\,z_{16} + z_{41}\,z_7)$$
$$z_{107} = -z_{96}\,(z_{33}\,z_{15} + z_{34}\,z_7) - z_{97}\,(z_{39}\,z_{15} + z_{40}\,z_7) - z_{98}\,(z_{30}\,z_{15} + z_{31}\,z_7)$$
$$z_{108} = z_{97}\,(z_{57}\,z_{69} + z_{61}\,z_{71})$$
$$z_{109} = z_{97}\,(z_{57}\,z_{68} + z_{61}\,z_{70})$$
$$z_{110} = I_{11}^F\,p$$
$$z_{111} = I_{22}^F\,q$$
$$z_{112} = I_{33}^F\,r$$
$$z_{113} = p\,z_{111} - q\,z_{110}$$
$$z_{114} = r\,z_{110} - p\,z_{112}$$
$$z_{115} = q\,z_{112} - r\,z_{111}$$
$$z_{116} = I_{11}^{MR}\,p$$
$$z_{117} = I_{22}^{MR}\,q$$
$$z_{118} = I_{33}^{MR}\,z_{23}$$

$$z_{119} = I_{11}^{MR}\, z_{24}$$

$$z_{120} = I_{22}^{MR}\, z_{25}$$

$$z_{121} = p\, z_{117} - q\, z_{116}$$

$$z_{122} = z_{23}\, z_{116} - p\, z_{118}$$

$$z_{123} = q\, z_{118} - z_{23}\, z_{117}$$

$$z_{124} = z_7\, z_{57} - z_5\, z_{55}$$

$$z_{125} = -z_5\, z_{58} - z_7\, z_{61} - z_{12}\, z_{59}$$

$$z_{126} = z_{12}\, z_{56} - z_5\, z_{60} - z_7\, z_{62}$$

$$z_{127} = -z_{10}\, z_{55} - z_{15}\, z_{57}$$

$$z_{128} = z_{15}\, z_{61} - z_{10}\, z_{58} - z_{13}\, z_{59}$$

$$z_{129} = z_{13}\, z_{56} + z_{15}\, z_{62} - z_{10}\, z_{60}$$

$$z_{130} = -z_{11}\, z_{55} - z_{16}\, z_{57}$$

$$z_{131} = z_{16}\, z_{61} - z_{11}\, z_{58} - z_{14}\, z_{59}$$

$$z_{132} = z_{14}\, z_{56} + z_{16}\, z_{62} - z_{11}\, z_{60}$$

$$z_{133} = m_F\,(z_{33}\, z_{10} - z_{34}\, z_5) + l_{\mathfrak{p}}\,(z_{39}\, z_{10} - z_{40}\, z_5) + m_{MR}\,(z_{30}\, z_{10} - z_{31}\, z_5)$$

$$z_{134} = z_{26}\,(z_5\, z_7 - z_{10}\, z_{15} - z_{11}\, z_{16})$$

$$z_{135} = -m_F\,(z_{33}\, z_{11} - z_{35}\, z_5) - l_{\mathfrak{p}}\,(z_{39}\, z_{11} - z_{41}\, z_5) - m_{MR}\,(z_{30}\, z_{11} - z_{32}\, z_5)$$

$$z_{136} = l_{\mathfrak{p}} + m_F\,(z_5^2 + z_{10}^2 + z_{11}^2) + m_{MR}\,(z_5^2 + z_{10}^2 + z_{11}^2)$$

$$z_{137} = z_{26}\,(z_5\, z_{12} + z_{10}\, z_{13} + z_{11}\, z_{14})$$

$$z_{138} = m_F\,(z_{34}\, z_{11} - z_{35}\, z_{10}) + l_{\mathfrak{p}}\,(z_{40}\, z_{11} - z_{41}\, z_{10}) + m_{MR}\,(z_{31}\, z_{11} - z_{32}\, z_{10})$$

$$z_{139} = l_{\mathfrak{p}}\,(z_{55}\, z_{68} - z_{58}\, z_{70})$$

$$z_{140} = l_{\mathfrak{p}}\,(z_{55}\, z_{69} - z_{58}\, z_{71})$$

$$\begin{aligned} z_{141} = {} & m_F\,(z_5\, z_{45} + z_{10}\, z_{46} + z_{11}\, z_{47}) + m_{MR}\,(z_5\, z_{42} + z_{10}\, z_{43} + z_{11}\, z_{44}) \\ & + l_{\mathfrak{p}}\,(z_5\, z_{90} + z_{10}\, z_{91} + z_{11}\, z_{92} - z_{55}\, z_{93} - z_{58}\, z_{94} - z_{60}\, z_{95}) \end{aligned}$$

$$z_{142} = m_F\,(z_{33}\, z_{13} - z_{34}\, z_{12}) + l_{\mathfrak{p}}\,(z_{39}\, z_{13} - z_{40}\, z_{12}) + m_{MR}\,(z_{30}\, z_{13} - z_{31}\, z_{12})$$

$$z_{143} = z_{26}\,(z_7\, z_{12} - z_{13}\, z_{15} - z_{14}\, z_{16})$$

$$z_{144} = -m_F\,(z_{33}\, z_{14} - z_{35}\, z_{12}) - l_{\mathfrak{p}}\,(z_{39}\, z_{14} - z_{41}\, z_{12}) - m_{MR}\,(z_{30}\, z_{14} - z_{32}\, z_{12})$$

$$z_{145} = l_{\mathfrak{p}} + m_F\,(z_{12}^2 + z_{13}^2 + z_{14}^2) + m_{MR}\,(z_{12}^2 + z_{13}^2 + z_{14}^2)$$

$$z_{146} = m_F\,(z_{34}\, z_{14} - z_{35}\, z_{13}) + l_{\mathfrak{p}}\,(z_{40}\, z_{14} - z_{41}\, z_{13}) + m_{MR}\,(z_{31}\, z_{14} - z_{32}\, z_{13})$$

$$z_{147} = l_{\mathfrak{p}}\, z_{59}\, z_{70}$$

$$z_{148} = l_{\mathcal{P}}\, z_{59}\, z_{71}$$

$$\begin{aligned} z_{149} &= m_F\,(z_{12}\, z_{45} + z_{13}\, z_{46} + z_{14}\, z_{47}) + m_{MR}\,(z_{12}\, z_{42} + z_{13}\, z_{43} + z_{14}\, z_{44}) \\ &\quad + l_{\mathcal{P}}\,(z_{12}\, z_{90} + z_{13}\, z_{91} + z_{14}\, z_{92} + z_{56}\, z_{95} - z_{59}\, z_{94}) \end{aligned}$$

$$z_{150} = m_F\,(z_{33}\, z_{15} + z_{34}\, z_7) + l_{\mathcal{P}}\,(z_{39}\, z_{15} + z_{40}\, z_7) + m_{MR}\,(z_{30}\, z_{15} + z_{31}\, z_7)$$

$$z_{151} = l_{\mathcal{P}} + m_F\,(z_7^2 + z_{15}^2 + z_{16}^2) + m_{MR}\,(z_7^2 + z_{15}^2 + z_{16}^2)$$

$$z_{152} = -m_F\,(z_{33}\, z_{16} + z_{35}\, z_7) - l_{\mathcal{P}}\,(z_{39}\, z_{16} + z_{41}\, z_7) - m_{MR}\,(z_{30}\, z_{16} + z_{32}\, z_7)$$

$$z_{153} = m_F\,(z_{34}\, z_{16} - z_{35}\, z_{15}) + l_{\mathcal{P}}\,(z_{40}\, z_{16} - z_{41}\, z_{15}) + m_{MR}\,(z_{31}\, z_{16} - z_{32}\, z_{15})$$

$$z_{154} = l_{\mathcal{P}}\,(z_{57}\, z_{68} + z_{61}\, z_{70})$$

$$z_{155} = l_{\mathcal{P}}\,(z_{57}\, z_{69} + z_{61}\, z_{71})$$

$$\begin{aligned} z_{156} &= -m_F\,(z_7\, z_{45} - z_{15}\, z_{46} - z_{16}\, z_{47}) - m_{MR}\,(z_7\, z_{42} - z_{15}\, z_{43} - z_{16}\, z_{44}) \\ &\quad - l_{\mathcal{P}}\,(z_7\, z_{90} + z_{57}\, z_{93} - z_{15}\, z_{91} - z_{16}\, z_{92} - z_{61}\, z_{94} - z_{62}\, z_{95}) \end{aligned}$$

$$z_{157} = I_{11}^F + I_{11}^{MR} + m_F\,(z_{34}^2 + z_{35}^2) + l_{\mathcal{P}}\,(z_{40}^2 + z_{41}^2) + m_{MR}\,(z_{31}^2 + z_{32}^2)$$

$$z_{158} = -m_F\, z_{33}\, z_{35} - l_{\mathcal{P}}\, z_{39}\, z_{41} - m_{MR}\, z_{30}\, z_{32}$$

$$z_{159} = -m_F\, z_{33}\, z_{34} - l_{\mathcal{P}}\, z_{39}\, z_{40} - m_{MR}\, z_{30}\, z_{31}$$

$$z_{160} = l_{\mathcal{P}}\,(z_{40}\, z_{70}\, z_{131} + z_{41}\, z_{68}\, z_{127} - z_{40}\, z_{68}\, z_{130} - z_{41}\, z_{70}\, z_{128})$$

$$z_{161} = l_{\mathcal{P}}\,(z_{40}\, z_{71}\, z_{131} + z_{41}\, z_{69}\, z_{127} - z_{40}\, z_{69}\, z_{130} - z_{41}\, z_{71}\, z_{128})$$

$$\begin{aligned} z_{162} &= z_{115} + z_{123} + m_F\,(z_{34}\, z_{47} - z_{35}\, z_{46}) + m_{MR}\,(z_{31}\, z_{44} - z_{32}\, z_{43}) \\ &\quad + l_{\mathcal{P}}\,(z_{40}\, z_{92} + z_{40}\, z_{130}\, z_{93} + z_{40}\, z_{131}\, z_{94} + z_{40}\, z_{132}\, z_{95} - z_{41}\, z_{91} - z_{41}\, z_{127}\, z_{93} \\ &\qquad - z_{41}\, z_{128}\, z_{94} - z_{41}\, z_{129}\, z_{95}) - z_{119} \end{aligned}$$

$$z_{163} = I_{22}^F + I_{22}^{MR} + m_F\,(z_{33}^2 + z_{35}^2) + l_{\mathcal{P}}\,(z_{39}^2 + z_{41}^2) + m_{MR}\,(z_{30}^2 + z_{32}^2)$$

$$z_{164} = -m_F\, z_{34}\, z_{35} - l_{\mathcal{P}}\, z_{40}\, z_{41} - m_{MR}\, z_{31}\, z_{32}$$

$$z_{165} = l_{\mathcal{P}}\,(z_{39}\, z_{70}\, z_{131} + z_{41}\, z_{68}\, z_{124} - z_{39}\, z_{68}\, z_{130} - z_{41}\, z_{70}\, z_{125})$$

$$z_{166} = l_{\mathcal{P}}\,(z_{39}\, z_{71}\, z_{131} + z_{41}\, z_{69}\, z_{124} - z_{39}\, z_{69}\, z_{130} - z_{41}\, z_{71}\, z_{125})$$

$$\begin{aligned} z_{167} &= z_{114} + z_{120} + z_{122} - m_F\,(z_{33}\, z_{47} - z_{35}\, z_{45}) - m_{MR}\,(z_{30}\, z_{44} - z_{32}\, z_{42}) \\ &\quad - l_{\mathcal{P}}\,(z_{39}\, z_{92} + z_{39}\, z_{130}\, z_{93} + z_{39}\, z_{131}\, z_{94} + z_{39}\, z_{132}\, z_{95} - z_{41}\, z_{90} - z_{41}\, z_{124}\, z_{93} \\ &\qquad - z_{41}\, z_{125}\, z_{94} - z_{41}\, z_{126}\, z_{95}) \end{aligned}$$

$$z_{168} = I_{33}^F + I_{33}^{MR} + m_F\,(z_{33}^2 + z_{34}^2) + l_{\mathcal{P}}\,(z_{39}^2 + z_{40}^2) + m_{MR}\,(z_{30}^2 + z_{31}^2)$$

$$z_{169} = l_{\mathcal{P}}\,(z_{39}\, z_{70}\, z_{128} + z_{40}\, z_{68}\, z_{124} - z_{39}\, z_{68}\, z_{127} - z_{40}\, z_{70}\, z_{125})$$

$$z_{170} = l_{\mathcal{P}}\,(z_{39}\, z_{71}\, z_{128} + z_{40}\, z_{69}\, z_{124} - z_{39}\, z_{69}\, z_{127} - z_{40}\, z_{71}\, z_{125})$$

$$z_{171} = z_{113} + z_{121} + m_F\,(z_{33}\,z_{46} - z_{34}\,z_{45}) + m_{MR}\,(z_{30}\,z_{43} - z_{31}\,z_{42}) + l_{rp}\,(z_{39}\,z_{91} + z_{39}\,z_{127}\,z_{93} + z_{39}\,z_{128}\,z_{94} + z_{39}\,z_{129}\,z_{95} - z_{40}\,z_{90} - z_{40}\,z_{124}\,z_{93} - z_{40}\,z_{125}\,z_{94} - z_{40}\,z_{126}\,z_{95})$$

$$z_{172} = l_{rp}\,(z_{68}\,z_{69} + z_{70}\,z_{71})$$

$$z_{173} = l_{rp}\,(z_{69}^2 + z_{71}^2)$$

$$z_{174} = l_{rp}\,(z_{69}\,z_{93} + z_{69}\,z_{124}\,z_{90} + z_{69}\,z_{127}\,z_{91} + z_{69}\,z_{130}\,z_{92} - z_{71}\,z_{94} - z_{71}\,z_{125}\,z_{90} - z_{71}\,z_{128}\,z_{91} - z_{71}\,z_{131}\,z_{92})$$

$$z_{175} = l_{rp}\,(z_{68}^2 + z_{70}^2)$$

$$z_{176} = l_{rp}\,(z_{68}\,z_{93} + z_{68}\,z_{124}\,z_{90} + z_{68}\,z_{127}\,z_{91} + z_{68}\,z_{130}\,z_{92} - z_{70}\,z_{94} - z_{70}\,z_{125}\,z_{90} - z_{70}\,z_{128}\,z_{91} - z_{70}\,z_{131}\,z_{92})$$

# 4 Dynamic Equations of the Dual-Lift Model

The following equations describe the dynamics of the multi-lift model, presented in the thesis main document [Ber13, pages 76ff.], for two coupled helicopters (dual-lift configuration). The variables $z_{xyz}$ represent intermediate results, which are generated automatically.

$$\begin{aligned}
0 = {} & z_{644} - z_{414}\,\dot{u}_{h1} - z_{415}\,\dot{v}_{h1} - z_{416}\,\dot{w}_{h1} - z_{417}\,\dot{p}_{h1} - z_{418}\,\dot{q}_{h1} - z_{419}\,\dot{r}_{h1} \\
& - z_{420}\,\dot{u}_{h2} - z_{421}\,\dot{v}_{h2} - z_{422}\,\dot{w}_{h2} - z_{423}\,\dot{p}_{h2} - z_{424}\,\dot{q}_{h2} - z_{425}\,\dot{r}_{h2} - z_{426}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{645} - z_{432}\,\dot{u}_{h1} - z_{433}\,\dot{v}_{h1} - z_{434}\,\dot{w}_{h1} - z_{435}\,\dot{p}_{h1} - z_{436}\,\dot{q}_{h1} - z_{437}\,\dot{r}_{h1} \\
& - z_{438}\,\dot{u}_{h2} - z_{439}\,\dot{v}_{h2} - z_{440}\,\dot{w}_{h2} - z_{441}\,\dot{p}_{h2} - z_{442}\,\dot{q}_{h2} - z_{443}\,\dot{r}_{h2} - z_{444}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{646} - z_{450}\,\dot{u}_{h1} - z_{451}\,\dot{v}_{h1} - z_{452}\,\dot{w}_{h1} - z_{453}\,\dot{p}_{h1} - z_{454}\,\dot{q}_{h1} - z_{455}\,\dot{r}_{h1} \\
& - z_{456}\,\dot{u}_{h2} - z_{457}\,\dot{v}_{h2} - z_{458}\,\dot{w}_{h2} - z_{459}\,\dot{p}_{h2} - z_{460}\,\dot{q}_{h2} - z_{461}\,\dot{r}_{h2} - z_{462}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{647} - z_{468}\,\dot{u}_{h1} - z_{469}\,\dot{v}_{h1} - z_{470}\,\dot{w}_{h1} - z_{471}\,\dot{p}_{h1} - z_{472}\,\dot{q}_{h1} - z_{473}\,\dot{r}_{h1} \\
& - z_{474}\,\dot{u}_{h2} - z_{475}\,\dot{v}_{h2} - z_{476}\,\dot{w}_{h2} - z_{477}\,\dot{p}_{h2} - z_{478}\,\dot{q}_{h2} - z_{479}\,\dot{r}_{h2} - z_{480}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{648} - z_{486}\,\dot{u}_{h1} - z_{487}\,\dot{v}_{h1} - z_{488}\,\dot{w}_{h1} - z_{489}\,\dot{p}_{h1} - z_{490}\,\dot{q}_{h1} - z_{491}\,\dot{r}_{h1} \\
& - z_{492}\,\dot{u}_{h2} - z_{493}\,\dot{v}_{h2} - z_{494}\,\dot{w}_{h2} - z_{495}\,\dot{p}_{h2} - z_{496}\,\dot{q}_{h2} - z_{497}\,\dot{r}_{h2} - z_{498}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{649} - z_{504}\,\dot{u}_{h1} - z_{505}\,\dot{v}_{h1} - z_{506}\,\dot{w}_{h1} - z_{507}\,\dot{p}_{h1} - z_{508}\,\dot{q}_{h1} - z_{509}\,\dot{r}_{h1} \\
& - z_{510}\,\dot{u}_{h2} - z_{511}\,\dot{v}_{h2} - z_{512}\,\dot{w}_{h2} - z_{513}\,\dot{p}_{h2} - z_{514}\,\dot{q}_{h2} - z_{515}\,\dot{r}_{h2} - z_{516}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{650} - z_{522}\,\dot{u}_{h1} - z_{523}\,\dot{v}_{h1} - z_{524}\,\dot{w}_{h1} - z_{525}\,\dot{p}_{h1} - z_{526}\,\dot{q}_{h1} - z_{527}\,\dot{r}_{h1} \\
& - z_{528}\,\dot{u}_{h2} - z_{529}\,\dot{v}_{h2} - z_{530}\,\dot{w}_{h2} - z_{531}\,\dot{p}_{h2} - z_{532}\,\dot{q}_{h2} - z_{533}\,\dot{r}_{h2} - z_{534}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{651} - z_{540}\,\dot{u}_{h1} - z_{541}\,\dot{v}_{h1} - z_{542}\,\dot{w}_{h1} - z_{543}\,\dot{p}_{h1} - z_{544}\,\dot{q}_{h1} - z_{545}\,\dot{r}_{h1} \\
& - z_{546}\,\dot{u}_{h2} - z_{547}\,\dot{v}_{h2} - z_{548}\,\dot{w}_{h2} - z_{549}\,\dot{p}_{h2} - z_{550}\,\dot{q}_{h2} - z_{551}\,\dot{r}_{h2} - z_{552}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{652} - z_{558}\,\dot{u}_{h1} - z_{559}\,\dot{v}_{h1} - z_{560}\,\dot{w}_{h1} - z_{561}\,\dot{p}_{h1} - z_{562}\,\dot{q}_{h1} - z_{563}\,\dot{r}_{h1} \\
& - z_{564}\,\dot{u}_{h2} - z_{565}\,\dot{v}_{h2} - z_{566}\,\dot{w}_{h2} - z_{567}\,\dot{p}_{h2} - z_{568}\,\dot{q}_{h2} - z_{569}\,\dot{r}_{h2} - z_{570}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{653} - z_{576}\,\dot{u}_{h1} - z_{577}\,\dot{v}_{h1} - z_{578}\,\dot{w}_{h1} - z_{579}\,\dot{p}_{h1} - z_{580}\,\dot{q}_{h1} - z_{581}\,\dot{r}_{h1} \\
& - z_{582}\,\dot{u}_{h2} - z_{583}\,\dot{v}_{h2} - z_{584}\,\dot{w}_{h2} - z_{585}\,\dot{p}_{h2} - z_{586}\,\dot{q}_{h2} - z_{587}\,\dot{r}_{h2} - z_{588}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{654} - z_{594}\,\dot{u}_{h1} - z_{595}\,\dot{v}_{h1} - z_{596}\,\dot{w}_{h1} - z_{597}\,\dot{p}_{h1} - z_{598}\,\dot{q}_{h1} - z_{599}\,\dot{r}_{h1} \\
& - z_{600}\,\dot{u}_{h2} - z_{601}\,\dot{v}_{h2} - z_{602}\,\dot{w}_{h2} - z_{603}\,\dot{p}_{h2} - z_{604}\,\dot{q}_{h2} - z_{605}\,\dot{r}_{h2} - z_{606}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}
0 = {} & z_{655} - z_{612}\,\dot{u}_{h1} - z_{613}\,\dot{v}_{h1} - z_{614}\,\dot{w}_{h1} - z_{615}\,\dot{p}_{h1} - z_{616}\,\dot{q}_{h1} - z_{617}\,\dot{r}_{h1} \\
& - z_{618}\,\dot{u}_{h2} - z_{619}\,\dot{v}_{h2} - z_{620}\,\dot{w}_{h2} - z_{621}\,\dot{p}_{h2} - z_{622}\,\dot{q}_{h2} - z_{623}\,\dot{r}_{h2} - z_{624}\,\dot{v}_{l}
\end{aligned}$$

$$\begin{aligned}0 = z_{656} &- z_{630}\,\dot{u}_{h1} - z_{631}\,\dot{v}_{h1} - z_{632}\,\dot{w}_{h1} - z_{633}\,\dot{p}_{h1} - z_{634}\,\dot{q}_{h1} - z_{635}\,\dot{r}_{h1} \\ &- z_{636}\,\dot{u}_{h2} - z_{637}\,\dot{v}_{h2} - z_{638}\,\dot{w}_{h2} - z_{639}\,\dot{p}_{h2} - z_{640}\,\dot{q}_{h2} - z_{641}\,\dot{r}_{h2} - z_{642}\,\dot{v}_{l}\end{aligned}$$

The equations need to be solved for the desired variables ($\dot{u}_{hx}$, $\dot{v}_{hx}$, $\dot{w}_{hx}$, $\dot{p}_{hx}$, $\dot{q}_{hx}$, $\dot{r}_{hx}$, $\dot{v}_{l}$), with $x \in \{1, 2, 3\}$, to get the explicit equations.

The following equations define the $z_{xyz}$ variables:

$$\begin{aligned}z_{6} &= \sin(\varphi_{h1}) \\ z_{36} &= \tan(\theta_{h1}) \\ z_{37} &= z_{6}\,z_{36} \\ z_{8} &= \cos(\varphi_{h1}) \\ z_{38} &= z_{8}\,z_{36} \\ \dot{\varphi}_{h1} &= p_{h1} + z_{37}\,q_{h1} + z_{38}\,r_{h1} \\ \dot{\theta}_{h1} &= z_{8}\,q_{h1} - z_{6}\,r_{h1} \\ z_{33} &= \cos(\theta_{h1}) \\ z_{34} &= z_{6}\,/\,z_{33} \\ z_{35} &= z_{8}\,/\,z_{33} \\ \dot{\psi}_{h1} &= z_{34}\,q_{h1} + z_{35}\,r_{h1} \\ z_{22} &= \sin(\varphi_{h2}) \\ z_{42} &= \tan(\theta_{h2}) \\ z_{43} &= z_{22}\,z_{42} \\ z_{24} &= \cos(\varphi_{h2}) \\ z_{44} &= z_{24}\,z_{42} \\ \dot{\varphi}_{h2} &= p_{h2} + z_{43}\,q_{h2} + z_{44}\,r_{h2} \\ \dot{\theta}_{h2} &= z_{24}\,q_{h2} - z_{22}\,r_{h2} \\ z_{39} &= \cos(\theta_{h2}) \\ z_{40} &= z_{22}\,/\,z_{39} \\ z_{41} &= z_{24}\,/\,z_{39} \\ \dot{\psi}_{h2} &= z_{40}\,q_{h2} + z_{41}\,r_{h2} \\ z_{55} &= x_{h2} - x_{h1} \\ z_{56} &= y_{h2} - y_{h1} \\ z_{57} &= z_{h2} - z_{h1}\end{aligned}$$

$$
\begin{aligned}
z_{58} &= z_{55}^2 + z_{56}^2 + z_{57}^2 \\
z_{59} &= z_{58}^{0.5} \\
z_{60} &= z_{55} / z_{59} \\
z_{129} &= z_{h1} - z_l \\
z_{65} &= z_l - z_{h1} \\
z_{63} &= x_l - x_{h1} \\
z_{64} &= y_l - y_{h1} \\
z_{66} &= z_{63}^2 + z_{64}^2 + z_{65}^2 \\
z_{67} &= z_{66}^{0.5} \\
z_{70} &= z_{65} / z_{67} \\
z_{62} &= z_{57} / z_{59} \\
z_{68} &= z_{63} / z_{67} \\
z_{61} &= z_{56} / z_{59} \\
z_{69} &= z_{64} / z_{67} \\
z_{51} &= m_F + m_{MR} \\
z_{53} &= (dOFo_2 m_F + dOMRo_2 m_{MR}) / z_{51} \\
z_{98} &= dORo_2 - z_{53} \\
z_2 &= \pi + \theta_{h1} \\
z_4 &= \cos(z_2) \\
z_{15} &= z_4 z_6 \\
z_{54} &= (dOFo_3 m_F + dOMRo_3 m_{MR}) / z_{51} \\
z_{99} &= dORo_3 - z_{54} \\
z_{16} &= z_4 z_8 \\
z_{127} &= x_{h1} - x_l \\
z_{52} &= (dOFo_1 m_F + dOMRo_1 m_{MR}) / z_{51} \\
z_{97} &= dORo_1 - z_{52} \\
z_1 &= \pi + \psi_{h1} \\
z_3 &= \cos(z_1) \\
z_5 &= z_3 z_4 \\
z_7 &= \sin(z_2)
\end{aligned}
$$

$$
\begin{aligned}
z_{9} &= \sin(z_{1}) \\
z_{10} &= z_{3}\, z_{6}\, z_{7} - z_{8}\, z_{9} \\
z_{11} &= z_{6}\, z_{9} + z_{3}\, z_{7}\, z_{8} \\
z_{128} &= y_{h1} - y_{l} \\
z_{12} &= z_{4}\, z_{9} \\
z_{13} &= z_{3}\, z_{8} + z_{6}\, z_{7}\, z_{9} \\
z_{14} &= z_{7}\, z_{8}\, z_{9} - z_{3}\, z_{6} \\
z_{160} &= 2z_{129}\left(z_{60}\left(z_{60}\, z_{70} - z_{62}\, z_{68}\right) + z_{61}\left(z_{61}\, z_{70} - z_{62}\, z_{69}\right)\right) \\
&\quad + 2z_{98}\, z_{15}\left(z_{60}\left(z_{60}\, z_{70} - z_{62}\, z_{68}\right) + z_{61}\left(z_{61}\, z_{70} - z_{62}\, z_{69}\right)\right) \\
&\quad + 2z_{99}\, z_{16}\left(z_{60}\left(z_{60}\, z_{70} - z_{62}\, z_{68}\right) + z_{61}\left(z_{61}\, z_{70} - z_{62}\, z_{69}\right)\right) - 2z_{62}\, z_{127} - 2z_{97}\, z_{5}\, z_{62} \\
&\quad - 2z_{98}\, z_{10}\, z_{62} - 2z_{99}\, z_{11}\, z_{62} - 2z_{128}\left(z_{60}\, z_{69} - z_{61}\, z_{68}\right) - 2z_{97}\, z_{12}\left(z_{60}\, z_{69} - z_{61}\, z_{68}\right) \\
&\quad - 2z_{98}\, z_{13}\left(z_{60}\, z_{69} - z_{61}\, z_{68}\right) - 2z_{99}\, z_{14}\left(z_{60}\, z_{69} - z_{61}\, z_{68}\right) \\
&\quad - 2z_{97}\, z_{7}\left(z_{60}\left(z_{60}\, z_{70} - z_{62}\, z_{68}\right) + z_{61}\left(z_{61}\, z_{70} - z_{62}\, z_{69}\right)\right) \\
z_{18} &= \pi + \theta_{h2} \\
z_{20} &= \cos(z_{18}) \\
z_{143} &= z_{h2} - z_{l} \\
z_{142} &= y_{h2} - y_{l} \\
z_{17} &= \pi + \psi_{h2} \\
z_{19} &= \cos(z_{17}) \\
z_{21} &= z_{19}\, z_{20} \\
z_{23} &= \sin(z_{18}) \\
z_{25} &= \sin(z_{17}) \\
z_{150} &= z_{23}\, z_{25} \\
z_{153} &= z_{22}\, z_{23} \\
z_{32} &= z_{20}\, z_{24} \\
z_{141} &= x_{h2} - x_{l} \\
z_{144} &= z_{19}\, z_{23} \\
z_{28} &= z_{20}\, z_{25} \\
z_{154} &= z_{23}\, z_{24} \\
z_{31} &= z_{20}\, z_{22} \\
z_{145} &= z_{19}\, z_{20}\, z_{22} \\
z_{27} &= z_{22}\, z_{25} + z_{19}\, z_{23}\, z_{24} \\
z_{146} &= -z_{19}\, z_{24} - z_{22}\, z_{23}\, z_{25} \\
z_{151} &= z_{20}\, z_{22}\, z_{25}
\end{aligned}
$$

$$z_{26} = z_{19}\, z_{22}\, z_{23} - z_{24}\, z_{25}$$

$$z_{30} = z_{23}\, z_{24}\, z_{25} - z_{19}\, z_{22}$$

$$z_{149} = z_{19}\, z_{20}\, z_{24}$$

$$z_{148} = z_{19}\, z_{22} - z_{23}\, z_{24}\, z_{25}$$

$$z_{147} = z_{24}\, z_{25} - z_{19}\, z_{22}\, z_{23}$$

$$z_{152} = z_{20}\, z_{24}\, z_{25}$$

$$\begin{aligned} z_{164} = {} & 2z_{97}\, z_{20}\, z_{22}\, z_{143} + 2z_{97}\, z_{142}\, (z_{21}\, z_{41} + z_{22}\, z_{150}) + 2z_{98}\, z_{143}\, (z_{22}\, z_{153} + z_{32}\, z_{44}) \\ & + 2z_{97}\, z_{141}\, (z_{22}\, z_{144} - z_{28}\, z_{41}) + 2z_{99}\, z_{143}\, (z_{22}\, z_{154} - z_{31}\, z_{44}) \\ & - 2z_{98}\, z_{141}\, (z_{22}\, z_{145} - z_{27}\, z_{44} - z_{41}\, z_{146}) - 2z_{98}\, z_{142}\, (z_{22}\, z_{151} - z_{26}\, z_{41} - z_{30}\, z_{44}) \\ & - 2z_{99}\, z_{141}\, (z_{22}\, z_{149} - z_{41}\, z_{148} - z_{44}\, z_{147}) - 2z_{99}\, z_{142}\, (z_{22}\, z_{152} - z_{27}\, z_{41} - z_{44}\, z_{146}) \end{aligned}$$

$$\begin{aligned} z_{158} = {} & 2z_{97}\, z_7\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68})) - 2z_{60}\, z_{127} \\ & - 2z_{97}\, z_5\, z_{60} - 2z_{98}\, z_{10}\, z_{60} - 2z_{99}\, z_{11}\, z_{60} - 2z_{128}\, (z_{61}\, z_{70} - z_{62}\, z_{69}) \\ & - 2z_{97}\, z_{12}\, (z_{61}\, z_{70} - z_{62}\, z_{69}) - 2z_{98}\, z_{13}\, (z_{61}\, z_{70} - z_{62}\, z_{69}) \\ & - 2z_{99}\, z_{14}\, (z_{61}\, z_{70} - z_{62}\, z_{69}) - 2z_{129}\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68})) \\ & - 2z_{98}\, z_{15}\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68})) \\ & - 2z_{99}\, z_{16}\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68})) \end{aligned}$$

$$z_{29} = z_{19}\, z_{24} + z_{22}\, z_{23}\, z_{25}$$

$$\begin{aligned} z_{169} = {} & 2z_{143}\, (z_{60}\, (z_{60}\, z_{70} - z_{62}\, z_{68}) + z_{61}\, (z_{61}\, z_{70} - z_{62}\, z_{69})) \\ & + 2z_{98}\, z_{31}\, (z_{60}\, (z_{60}\, z_{70} - z_{62}\, z_{68}) + z_{61}\, (z_{61}\, z_{70} - z_{62}\, z_{69})) \\ & + 2z_{99}\, z_{32}\, (z_{60}\, (z_{60}\, z_{70} - z_{62}\, z_{68}) + z_{61}\, (z_{61}\, z_{70} - z_{62}\, z_{69})) - 2z_{62}\, z_{141} - 2z_{97}\, z_{21}\, z_{62} \\ & - 2z_{98}\, z_{26}\, z_{62} - 2z_{99}\, z_{27}\, z_{62} - 2z_{142}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) - 2z_{97}\, z_{28}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) \\ & - 2z_{98}\, z_{29}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) - 2z_{99}\, z_{30}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) \\ & - 2z_{97}\, z_{23}\, (z_{60}\, (z_{60}\, z_{70} - z_{62}\, z_{68}) + z_{61}\, (z_{61}\, z_{70} - z_{62}\, z_{69})) \end{aligned}$$

$$\begin{aligned} z_{167} = {} & 2z_{97}\, z_{23}\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68})) - 2z_{60}\, z_{141} \\ & - 2z_{97}\, z_{21}\, z_{60} - 2z_{98}\, z_{26}\, z_{60} - 2z_{99}\, z_{27}\, z_{60} - 2z_{142}\, (z_{61}\, z_{70} - z_{62}\, z_{69}) \\ & - 2z_{97}\, z_{28}\, (z_{61}\, z_{70} - z_{62}\, z_{69}) - 2z_{98}\, z_{29}\, (z_{61}\, z_{70} - z_{62}\, z_{69}) \\ & - 2z_{99}\, z_{30}\, (z_{61}\, z_{70} - z_{62}\, z_{69}) - 2z_{143}\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68})) \\ & - 2z_{98}\, z_{31}\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68})) \\ & - 2z_{99}\, z_{32}\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68})) \end{aligned}$$

$$z_{173} = z_{158}\, z_{169} - z_{160}\, z_{167}$$

$$z_{181} = z_{160}\, z_{164} \,/ z_{173}$$

$$\begin{aligned} z_{165} = {} & 2z_{97}\, z_{142}\, (z_{21}\, z_{40} - z_{24}\, z_{150}) + 2z_{98}\, z_{141}\, (z_{24}\, z_{145} + z_{27}\, z_{43} + z_{40}\, z_{146}) \\ & + 2z_{98}\, z_{142}\, (z_{24}\, z_{151} + z_{26}\, z_{40} + z_{30}\, z_{43}) + 2z_{99}\, z_{141}\, (z_{24}\, z_{149} + z_{40}\, z_{148} + z_{43}\, z_{147}) \\ & + 2z_{99}\, z_{142}\, (z_{24}\, z_{152} + z_{27}\, z_{40} + z_{43}\, z_{146}) \\ & - 2z_{97}\, z_{20}\, z_{24}\, z_{143} - 2z_{97}\, z_{141}\, (z_{24}\, z_{144} + z_{28}\, z_{40}) \\ & - 2z_{99}\, z_{143}\, (z_{24}\, z_{154} + z_{31}\, z_{43}) - 2z_{98}\, z_{143}\, (z_{24}\, z_{153} - z_{32}\, z_{43}) \end{aligned}$$

$$z_{182} = z_{160}\, z_{165} \,/ z_{173}$$

$$z_{166} = 2z_{141} + 2z_{97}\,z_{21} + 2z_{98}\,z_{26} + 2z_{99}\,z_{27}$$

$$z_{183} = z_{160}\,z_{166}\,/z_{173}$$

$$\begin{aligned} z_{170} = {} & 2z_{98}\,z_{27}\,z_{141} + 2z_{98}\,z_{30}\,z_{142} + 2z_{98}\,z_{32}\,z_{143} \\ & + 2z_{99}\,z_{141}\,z_{147} + 2z_{99}\,z_{142}\,z_{146} - 2z_{99}\,z_{31}\,z_{143} \end{aligned}$$

$$z_{184} = z_{160}\,z_{170}\,/z_{173}$$

$$z_{171} = 2z_{142} + 2z_{97}\,z_{28} + 2z_{98}\,z_{29} + 2z_{99}\,z_{30}$$

$$z_{185} = z_{160}\,z_{171}\,/z_{173}$$

$$z_{172} = 2z_{143} + 2z_{98}\,z_{31} + 2z_{99}\,z_{32} - 2z_{97}\,z_{23}$$

$$z_{186} = z_{160}\,z_{172}\,/z_{173}$$

$$z_{136} = z_7\,z_9$$

$$z_{139} = z_6\,z_7$$

$$z_{130} = z_3\,z_7$$

$$z_{140} = z_7\,z_8$$

$$z_{131} = z_3\,z_4\,z_6$$

$$z_{132} = -z_3\,z_8 - z_6\,z_7\,z_9$$

$$z_{137} = z_4\,z_6\,z_9$$

$$z_{135} = z_3\,z_4\,z_8$$

$$z_{134} = z_3\,z_6 - z_7\,z_8\,z_9$$

$$z_{133} = z_8\,z_9 - z_3\,z_6\,z_7$$

$$z_{138} = z_4\,z_8\,z_9$$

$$\begin{aligned} z_{155} = {} & 2z_{97}\,z_4\,z_6\,z_{129} + 2z_{97}\,z_{128}\,(z_5\,z_{35} + z_6\,z_{136}) + 2z_{98}\,z_{129}\,(z_6\,z_{139} + z_{16}\,z_{38}) \\ & + 2z_{97}\,z_{127}\,(z_6\,z_{130} - z_{12}\,z_{35}) + 2z_{99}\,z_{129}\,(z_6\,z_{140} - z_{15}\,z_{38}) \\ & - 2z_{98}\,z_{127}\,(z_6\,z_{131} - z_{11}\,z_{38} - z_{35}\,z_{132}) - 2z_{98}\,z_{128}\,(z_6\,z_{137} - z_{10}\,z_{35} - z_{14}\,z_{38}) \\ & - 2z_{99}\,z_{127}\,(z_6\,z_{135} - z_{35}\,z_{134} - z_{38}\,z_{133}) - 2z_{99}\,z_{128}\,(z_6\,z_{138} - z_{11}\,z_{35} - z_{38}\,z_{132}) \end{aligned}$$

$$z_{174} = z_{155}\,z_{169}\,/z_{173}$$

$$\begin{aligned} z_{156} = {} & 2z_{97}\,z_{128}\,(z_5\,z_{34} - z_8\,z_{136}) + 2z_{98}\,z_{127}\,(z_8\,z_{131} + z_{11}\,z_{37} + z_{34}\,z_{132}) \\ & + 2z_{98}\,z_{128}\,(z_8\,z_{137} + z_{10}\,z_{34} + z_{14}\,z_{37}) + 2z_{99}\,z_{127}\,(z_8\,z_{135} + z_{34}\,z_{134} + z_{37}\,z_{133}) \\ & + 2z_{99}\,z_{128}\,(z_8\,z_{138} + z_{11}\,z_{34} + z_{37}\,z_{132}) - 2z_{97}\,z_4\,z_8\,z_{129} - 2z_{97}\,z_{127}\,(z_8\,z_{130} + z_{12}\,z_{34}) \\ & - 2z_{99}\,z_{129}\,(z_8\,z_{140} + z_{15}\,z_{37}) - 2z_{98}\,z_{129}\,(z_8\,z_{139} - z_{16}\,z_{37}) \end{aligned}$$

$$z_{175} = z_{156}\,z_{169}\,/z_{173}$$

$$z_{157} = 2z_{127} + 2z_{97}\,z_5 + 2z_{98}\,z_{10} + 2z_{99}\,z_{11}$$

$$z_{176} = z_{157}\,z_{169}\,/z_{173}$$

$$
\begin{aligned}
z_{159} &= 2z_{128}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + 2z_{97}\,z_{12}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + 2z_{98}\,z_{13}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) \\
&\quad + 2z_{99}\,z_{14}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + 2z_{129}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69})) \\
&\quad + 2z_{98}\,z_{15}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69})) \\
&\quad + 2z_{99}\,z_{16}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69})) - 2z_{61}\,z_{127} - 2z_{97}\,z_5\,z_{61} \\
&\quad - 2z_{98}\,z_{10}\,z_{61} - 2z_{99}\,z_{11}\,z_{61} - 2z_{97}\,z_7\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{168} &= 2z_{142}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + 2z_{97}\,z_{28}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + 2z_{98}\,z_{29}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) \\
&\quad + 2z_{99}\,z_{30}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + 2z_{143}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69})) \\
&\quad + 2z_{98}\,z_{31}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69})) \\
&\quad + 2z_{99}\,z_{32}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69})) - 2z_{61}\,z_{141} - 2z_{97}\,z_{21}\,z_{61} \\
&\quad - 2z_{98}\,z_{26}\,z_{61} - 2z_{99}\,z_{27}\,z_{61} - 2z_{97}\,z_{23}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$z_{177} = (z_{159}\,z_{169} - z_{160}\,z_{168})/z_{173}$$

$$
\begin{aligned}
z_{161} &= 2z_{98}\,z_{11}\,z_{127} + 2z_{98}\,z_{14}\,z_{128} + 2z_{98}\,z_{16}\,z_{129} \\
&\quad + 2z_{99}\,z_{127}\,z_{133} + 2z_{99}\,z_{128}\,z_{132} - 2z_{99}\,z_{15}\,z_{129}
\end{aligned}
$$

$$z_{178} = z_{161}\,z_{169}\,/z_{173}$$

$$z_{162} = 2z_{128} + 2z_{97}\,z_{12} + 2z_{98}\,z_{13} + 2z_{99}\,z_{14}$$

$$z_{179} = z_{162}\,z_{169}\,/z_{173}$$

$$z_{163} = 2z_{129} + 2z_{98}\,z_{15} + 2z_{99}\,z_{16} - 2z_{97}\,z_7$$

$$z_{180} = z_{163}\,z_{169}\,/z_{173}$$

$$
\begin{aligned}
u_l &= z_{181}\,r_{h2} + z_{182}\,q_{h2} + z_{183}\,u_{h2} + z_{184}\,p_{h2} + z_{185}\,v_{h2} + z_{186}\,w_{h2} - z_{174}\,r_{h1} \\
&\quad - z_{175}\,q_{h1} - z_{176}\,u_{h1} - z_{177}\,v_l - z_{178}\,p_{h1} - z_{179}\,v_{h1} - z_{180}\,w_{h1}
\end{aligned}
$$

$$z_{187} = z_{155}\,z_{167}\,/z_{173}$$

$$z_{188} = z_{156}\,z_{167}\,/z_{173}$$

$$z_{189} = z_{157}\,z_{167}\,/z_{173}$$

$$z_{191} = z_{161}\,z_{167}\,/z_{173}$$

$$z_{192} = z_{162}\,z_{167}\,/z_{173}$$

$$z_{193} = z_{163}\,z_{167}\,/z_{173}$$

$$z_{190} = (z_{158}\,z_{168} - z_{159}\,z_{167})/z_{173}$$

$$z_{194} = z_{158}\,z_{164}\,/z_{173}$$

$$z_{195} = z_{158}\,z_{165}\,/z_{173}$$

$$z_{196} = z_{158}\,z_{166}\,/z_{173}$$

$$z_{197} = z_{158}\,z_{170}\,/z_{173}$$

$$z_{198} = z_{158}\,z_{171}\,/z_{173}$$

$$
\begin{aligned}
z_{199} &= z_{158}\, z_{172}\, / z_{173} \\
w_l &= z_{187}\, r_{h1} + z_{188}\, q_{h1} + z_{189}\, u_{h1} + z_{191}\, p_{h1} + z_{192}\, v_{h1} + z_{193}\, w_{h1} - z_{190}\, v_l \\
&\quad - z_{194}\, r_{h2} - z_{195}\, q_{h2} - z_{196}\, u_{h2} - z_{197}\, p_{h2} - z_{198}\, v_{h2} - z_{199}\, w_{h2} \\
\dot{x}_l &= z_{60}\, u_l + z_{61}\, v_l + z_{62}\, w_l \\
\dot{y}_l &= (z_{60}\, z_{69} - z_{61}\, z_{68}) w_l + (z_{61}\, z_{70} - z_{62}\, z_{69}) u_l - (z_{60}\, z_{70} - z_{62}\, z_{68}) v_l \\
\dot{z}_l &= (z_{61}\,(z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\,(z_{60}\, z_{70} - z_{62}\, z_{68})) u_l \\
&\quad - (z_{60}\,(z_{60}\, z_{70} - z_{62}\, z_{68}) + z_{61}\,(z_{61}\, z_{70} - z_{62}\, z_{69})) w_l \\
&\quad - (z_{60}\,(z_{60}\, z_{69} - z_{61}\, z_{68}) - z_{62}\,(z_{61}\, z_{70} - z_{62}\, z_{69})) v_l \\
z_{45} &= \omega_{MR} + r_{h1} \\
z_{46} &= q_{h1}\,(r_{h1} - z_{45}) \\
z_{47} &= p_{h1}\,(r_{h1} - z_{45}) \\
z_{48} &= \omega_{MR} + r_{h2} \\
z_{49} &= q_{h2}\,(r_{h2} - z_{48}) \\
z_{50} &= p_{h2}\,(r_{h2} - z_{48}) \\
z_{71} &= -2 z_{55}\,(u_{h1} - u_{h2}) - 2 z_{56}\,(v_{h1} - v_{h2}) - 2 z_{57}\,(w_{h1} - w_{h2}) \\
z_{72} &= (2 z_{59}\,(u_{h1} - u_{h2}) + z_{55}\, z_{71}\, / z_{58}^{0.5}) / z_{59}^2 \\
z_{73} &= (2 z_{59}\,(v_{h1} - v_{h2}) + z_{56}\, z_{71}\, / z_{58}^{0.5}) / z_{59}^2 \\
z_{74} &= (2 z_{59}\,(w_{h1} - w_{h2}) + z_{57}\, z_{71}\, / z_{58}^{0.5}) / z_{59}^2 \\
z_{75} &= -0.5 u_l\, z_{72} - 0.5 v_l\, z_{73} - 0.5 w_l\, z_{74} \\
z_{76} &= -2 z_{63}\,(u_{h1} - \dot{x}_l) - 2 z_{64}\,(v_{h1} - \dot{y}_l) - 2 z_{65}\,(w_{h1} - \dot{z}_l) \\
z_{77} &= (2 z_{67}\,(v_{h1} - \dot{y}_l) + z_{64}\, z_{76}\, / z_{66}^{0.5}) / z_{67}^2 \\
z_{78} &= (2 z_{67}\,(u_{h1} - \dot{x}_l) + z_{63}\, z_{76}\, / z_{66}^{0.5}) / z_{67}^2 \\
z_{79} &= (2 z_{67}\,(w_{h1} - \dot{z}_l) + z_{65}\, z_{76}\, / z_{66}^{0.5}) / z_{67}^2 \\
z_{80} &= z_{60}\, z_{69} - z_{61}\, z_{68} \\
z_{81} &= z_{61}\, z_{70} - z_{62}\, z_{69} \\
z_{82} &= z_{62}\, z_{68} - z_{60}\, z_{70} \\
z_{83} &= 0.5 v_l\,(z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}) - 0.5 u_l\,(z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77}) \\
&\quad - 0.5 w_l\,(z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
z_{84} &= z_{61}\,(z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\,(z_{60}\, z_{70} - z_{62}\, z_{68}) \\
z_{85} &= -z_{60}\,(z_{60}\, z_{70} - z_{62}\, z_{68}) - z_{61}\,(z_{61}\, z_{70} - z_{62}\, z_{69})
\end{aligned}
$$

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\begin{aligned}
z_{86} &= z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69}) - z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) \\
z_{87} &= 0.5 w_l\,((z_{60}\,z_{70} - z_{62}\,z_{68}) z_{72} + (z_{61}\,z_{70} - z_{62}\,z_{69}) z_{73} \\
&\qquad + z_{60}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}) \\
&\qquad + z_{61}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77})) \\
&\quad + 0.5 v_l\,((z_{60}\,z_{69} - z_{61}\,z_{68}) z_{72} + z_{60}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\qquad - (z_{61}\,z_{70} - z_{62}\,z_{69}) z_{74} - z_{62}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77})) \\
&\quad - 0.5 u_l\,((z_{60}\,z_{69} - z_{61}\,z_{68}) z_{73} + (z_{60}\,z_{70} - z_{62}\,z_{68}) z_{74} \\
&\qquad + z_{61}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\qquad + z_{62}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78})) \\
z_{88} &= dOMRo_1 - z_{52} \\
z_{89} &= dOMRo_2 - z_{53} \\
z_{90} &= dOMRo_3 - z_{54} \\
z_{91} &= dOFo_1 - z_{52} \\
z_{92} &= dOFo_2 - z_{53} \\
z_{93} &= dOFo_3 - z_{54} \\
z_{94} &= dOT_1 - z_{52} \\
z_{96} &= dOT_3 - z_{54} \\
z_{100} &= -q_{h1}\,(z_{88}\,q_{h1} - z_{89}\,p_{h1}) - r_{h1}\,(z_{88}\,r_{h1} - z_{90}\,p_{h1}) \\
z_{101} &= p_{h1}\,(z_{88}\,q_{h1} - z_{89}\,p_{h1}) - r_{h1}\,(z_{89}\,r_{h1} - z_{90}\,q_{h1}) \\
z_{102} &= p_{h1}\,(z_{88}\,r_{h1} - z_{90}\,p_{h1}) + q_{h1}\,(z_{89}\,r_{h1} - z_{90}\,q_{h1}) \\
z_{103} &= -q_{h1}\,(z_{91}\,q_{h1} - z_{92}\,p_{h1}) - r_{h1}\,(z_{91}\,r_{h1} - z_{93}\,p_{h1}) \\
z_{104} &= p_{h1}\,(z_{91}\,q_{h1} - z_{92}\,p_{h1}) - r_{h1}\,(z_{92}\,r_{h1} - z_{93}\,q_{h1}) \\
z_{105} &= p_{h1}\,(z_{91}\,r_{h1} - z_{93}\,p_{h1}) + q_{h1}\,(z_{92}\,r_{h1} - z_{93}\,q_{h1}) \\
z_{112} &= -q_{h2}\,(z_{88}\,q_{h2} - z_{89}\,p_{h2}) - r_{h2}\,(z_{88}\,r_{h2} - z_{90}\,p_{h2}) \\
z_{113} &= p_{h2}\,(z_{88}\,q_{h2} - z_{89}\,p_{h2}) - r_{h2}\,(z_{89}\,r_{h2} - z_{90}\,q_{h2}) \\
z_{114} &= p_{h2}\,(z_{88}\,r_{h2} - z_{90}\,p_{h2}) + q_{h2}\,(z_{89}\,r_{h2} - z_{90}\,q_{h2}) \\
z_{115} &= -q_{h2}\,(z_{91}\,q_{h2} - z_{92}\,p_{h2}) - r_{h2}\,(z_{91}\,r_{h2} - z_{93}\,p_{h2}) \\
z_{116} &= p_{h2}\,(z_{91}\,q_{h2} - z_{92}\,p_{h2}) - r_{h2}\,(z_{92}\,r_{h2} - z_{93}\,q_{h2}) \\
z_{117} &= p_{h2}\,(z_{91}\,r_{h2} - z_{93}\,p_{h2}) + q_{h2}\,(z_{92}\,r_{h2} - z_{93}\,q_{h2}) \\
z_{124} &= g\,m_F \\
z_{125} &= g\,m_{MR} \\
z_{126} &= g\,l_{\not p}
\end{aligned}
$$

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\begin{aligned}
z_{200} &= -z_3\, z_7\, \dot{\theta}_{h1} - z_4\, z_9\, \dot{\psi}_{h1} \\
z_{201} &= \sin(\theta_{h1}) \\
z_{202} &= (z_6\, z_{33}\, \dot{\varphi}_{h1} - z_8\, z_{201}\, \dot{\theta}_{h1})/z_{33}^2 \\
z_{203} &= z_3\, z_7\, \dot{\psi}_{h1} + z_4\, z_9\, \dot{\theta}_{h1} \\
z_{204} &= z_4\, z_6\, \dot{\theta}_{h1} + z_7\, z_8\, \dot{\varphi}_{h1} \\
z_{205} &= -z_4\, z_6\, \dot{\varphi}_{h1} - z_7\, z_8\, \dot{\theta}_{h1} \\
z_{206} &= z_8\, \dot{\theta}_{h1}/z_{33}^2 - z_6\, z_{36}\, \dot{\varphi}_{h1} \\
z_{207} &= z_3\, z_4\, \dot{\theta}_{h1} - z_7\, z_9\, \dot{\psi}_{h1} \\
z_{208} &= z_3\, z_4\, \dot{\psi}_{h1} - z_7\, z_9\, \dot{\theta}_{h1} \\
z_{209} &= z_4\, z_8\, \dot{\theta}_{h1} - z_6\, z_7\, \dot{\varphi}_{h1} \\
z_{210} &= z_4\, z_8\, \dot{\varphi}_{h1} - z_6\, z_7\, \dot{\theta}_{h1} \\
z_{211} &= z_3\, z_4\, z_8\, \dot{\varphi}_{h1} - z_3\, z_6\, z_7\, \dot{\theta}_{h1} - z_4\, z_6\, z_9\, \dot{\psi}_{h1} \\
z_{212} &= z_3\, z_6\, \dot{\psi}_{h1} + z_8\, z_9\, \dot{\varphi}_{h1} + z_3\, z_4\, z_8\, \dot{\theta}_{h1} - z_3\, z_6\, z_7\, \dot{\varphi}_{h1} - z_7\, z_8\, z_9\, \dot{\psi}_{h1} \\
z_{213} &= z_3\, z_6\, \dot{\varphi}_{h1} + z_8\, z_9\, \dot{\psi}_{h1} - z_3\, z_6\, z_7\, \dot{\psi}_{h1} - z_4\, z_6\, z_9\, \dot{\theta}_{h1} - z_7\, z_8\, z_9\, \dot{\varphi}_{h1} \\
z_{214} &= z_3\, z_4\, z_6\, \dot{\psi}_{h1} + z_4\, z_8\, z_9\, \dot{\varphi}_{h1} - z_6\, z_7\, z_9\, \dot{\theta}_{h1} \\
z_{215} &= z_6\, z_9\, \dot{\varphi}_{h1} + z_3\, z_4\, z_6\, \dot{\theta}_{h1} + z_3\, z_7\, z_8\, \dot{\varphi}_{h1} - z_3\, z_8\, \dot{\psi}_{h1} - z_6\, z_7\, z_9\, \dot{\psi}_{h1} \\
z_{216} &= z_6\, z_9\, \dot{\psi}_{h1} + z_3\, z_7\, z_8\, \dot{\psi}_{h1} + z_4\, z_8\, z_9\, \dot{\theta}_{h1} - z_3\, z_8\, \dot{\varphi}_{h1} - z_6\, z_7\, z_9\, \dot{\varphi}_{h1} \\
z_{217} &= -z_3\, z_4\, z_6\, \dot{\varphi}_{h1} - z_3\, z_7\, z_8\, \dot{\theta}_{h1} - z_4\, z_8\, z_9\, \dot{\psi}_{h1} \\
z_{218} &= z_3\, z_8\, \dot{\varphi}_{h1} + z_6\, z_7\, z_9\, \dot{\varphi}_{h1} - z_6\, z_9\, \dot{\psi}_{h1} - z_3\, z_7\, z_8\, \dot{\psi}_{h1} - z_4\, z_8\, z_9\, \dot{\theta}_{h1} \\
z_{219} &= z_3\, z_8\, \dot{\psi}_{h1} + z_6\, z_7\, z_9\, \dot{\psi}_{h1} - z_6\, z_9\, \dot{\varphi}_{h1} - z_3\, z_4\, z_6\, \dot{\theta}_{h1} - z_3\, z_7\, z_8\, \dot{\varphi}_{h1} \\
z_{220} &= z_3\, z_4\, z_8\, \dot{\psi}_{h1} - z_4\, z_6\, z_9\, \dot{\varphi}_{h1} - z_7\, z_8\, z_9\, \dot{\theta}_{h1} \\
z_{221} &= 2z_{97}\, z_4\, z_8\, z_{129}\, \dot{\varphi}_{h1} + 2z_{97}\, z_4\, z_6\, (w_{h1} - \dot{z}_l) \\
&\quad + 2z_{97}\, (z_5\, z_{35} + z_6\, z_{136})(v_{h1} - \dot{y}_l) + 2z_{98}\, (z_6\, z_{139} + z_{16}\, z_{38})(w_{h1} - \dot{z}_l) \\
&\quad + 2z_{97}\, (z_6\, z_{130} - z_{12}\, z_{35})(u_{h1} - \dot{x}_l) + 2z_{99}\, (z_6\, z_{140} - z_{15}\, z_{38})(w_{h1} - \dot{z}_l) \\
&\quad + 2z_{98}\, z_{129}\, (z_8\, z_{139}\, \dot{\varphi}_{h1} + z_6\, z_{204} + z_{16}\, z_{206} + z_{38}\, z_{205}) \\
&\quad + 2z_{97}\, z_{127}\, (z_8\, z_{130}\, \dot{\varphi}_{h1} + z_6\, z_{207} + z_{12}\, z_{202} - z_{35}\, z_{208}) \\
&\quad + 2z_{99}\, z_{129}\, (z_8\, z_{140}\, \dot{\varphi}_{h1} + z_6\, z_{209} - z_{15}\, z_{206} - z_{38}\, z_{210}) \\
&\quad + 2z_{98}\, z_{127}\, (z_{11}\, z_{206} + z_{35}\, z_{213} + z_{38}\, z_{212} - z_8\, z_{131}\, \dot{\varphi}_{h1} - z_6\, z_{211} - z_{132}\, z_{202}) \\
&\quad + 2z_{99}\, z_{127}\, (z_{35}\, z_{218} + z_{38}\, z_{219} + z_{133}\, z_{206} - z_8\, z_{135}\, \dot{\varphi}_{h1} - z_6\, z_{217} - z_{134}\, z_{202}) \\
&\quad - 2z_{97}\, z_6\, z_7\, z_{129}\, \dot{\theta}_{h1} - 2z_{98}\, (z_6\, z_{131} - z_{11}\, z_{38} - z_{35}\, z_{132})(u_{h1} - \dot{x}_l) \\
&\quad - 2z_{98}\, (z_6\, z_{137} - z_{10}\, z_{35} - z_{14}\, z_{38})(v_{h1} - \dot{y}_l) \\
&\quad - 2z_{99}\, (z_6\, z_{135} - z_{35}\, z_{134} - z_{38}\, z_{133})(u_{h1} - \dot{x}_l) \\
&\quad - 2z_{99}\, (z_6\, z_{138} - z_{11}\, z_{35} - z_{38}\, z_{132})(v_{h1} - \dot{y}_l) \\
&\quad - 2z_{97}\, z_{128}\, (z_5\, z_{202} - z_8\, z_{136}\, \dot{\varphi}_{h1} - z_6\, z_{203} - z_{35}\, z_{200}) \\
&\quad - 2z_{98}\, z_{128}\, (z_8\, z_{137}\, \dot{\varphi}_{h1} + z_6\, z_{214} + z_{10}\, z_{202} - z_{14}\, z_{206} - z_{35}\, z_{215} - z_{38}\, z_{216}) \\
&\quad - 2z_{99}\, z_{128}\, (z_8\, z_{138}\, \dot{\varphi}_{h1} + z_6\, z_{220} + z_{11}\, z_{202} - z_{35}\, z_{212} - z_{38}\, z_{213} - z_{132}\, z_{206})
\end{aligned}
$$

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\begin{aligned}
z_{222} &= (z_6\, z_{201}\, \dot{\theta}_{h1} + z_8\, z_{33}\, \dot{\varphi}_{h1})/z_{33}^2 \\
z_{223} &= z_8\, z_{36}\, \dot{\varphi}_{h1} + z_6\, \dot{\theta}_{h1}/z_{33}^2 \\
z_{224} &= 2z_{97}\, z_4\, z_6\, z_{129}\, \dot{\varphi}_{h1} + 2z_{97}\, z_7\, z_8\, z_{129}\, \dot{\theta}_{h1} + 2z_{97}\, (z_5\, z_{34} - z_8\, z_{136})(v_{h1} - \dot{y}_l) \\
&\quad + 2z_{98}\, (z_8\, z_{131} + z_{11}\, z_{37} + z_{34}\, z_{132})(u_{h1} - \dot{x}_l) \\
&\quad + 2z_{98}\, (z_8\, z_{137} + z_{10}\, z_{34} + z_{14}\, z_{37})(v_{h1} - \dot{y}_l) \\
&\quad + 2z_{99}\, (z_8\, z_{135} + z_{34}\, z_{134} + z_{37}\, z_{133})(u_{h1} - \dot{x}_l) \\
&\quad + 2z_{99}\, (z_8\, z_{138} + z_{11}\, z_{34} + z_{37}\, z_{132})(v_{h1} - \dot{y}_l) \\
&\quad + 2z_{97}\, z_{127}\, (z_6\, z_{130}\, \dot{\varphi}_{h1} - z_8\, z_{207} - z_{12}\, z_{222} - z_{34}\, z_{208}) \\
&\quad + 2z_{99}\, z_{129}\, (z_6\, z_{140}\, \dot{\varphi}_{h1} - z_8\, z_{209} - z_{15}\, z_{223} - z_{37}\, z_{210}) \\
&\quad - 2z_{97}\, z_4\, z_8\, (w_{h1} - \dot{z}_l) - 2z_{97}\, (z_8\, z_{130} + z_{12}\, z_{34})(u_{h1} - \dot{x}_l) \\
&\quad - 2z_{99}\, (z_8\, z_{140} + z_{15}\, z_{37})(w_{h1} - \dot{z}_l) - 2z_{98}\, (z_8\, z_{139} - z_{16}\, z_{37})(w_{h1} - \dot{z}_l) \\
&\quad - 2z_{97}\, z_{128}\, (z_8\, z_{203} - z_6\, z_{136}\, \dot{\varphi}_{h1} - z_5\, z_{222} - z_{34}\, z_{200}) \\
&\quad - 2z_{98}\, z_{129}\, (z_8\, z_{204} - z_6\, z_{139}\, \dot{\varphi}_{h1} - z_{16}\, z_{223} - z_{37}\, z_{205}) \\
&\quad - 2z_{98}\, z_{127}\, (z_6\, z_{131}\, \dot{\varphi}_{h1} - z_8\, z_{211} - z_{11}\, z_{223} - z_{34}\, z_{213} - z_{37}\, z_{212} - z_{132}\, z_{222}) \\
&\quad - 2z_{98}\, z_{128}\, (z_6\, z_{137}\, \dot{\varphi}_{h1} - z_8\, z_{214} - z_{10}\, z_{222} - z_{14}\, z_{223} - z_{34}\, z_{215} - z_{37}\, z_{216}) \\
&\quad - 2z_{99}\, z_{127}\, (z_6\, z_{135}\, \dot{\varphi}_{h1} - z_8\, z_{217} - z_{34}\, z_{218} - z_{37}\, z_{219} - z_{133}\, z_{223} - z_{134}\, z_{222}) \\
&\quad - 2z_{99}\, z_{128}\, (z_6\, z_{138}\, \dot{\varphi}_{h1} - z_8\, z_{220} - z_{11}\, z_{222} - z_{34}\, z_{212} - z_{37}\, z_{213} - z_{132}\, z_{223}) \\
z_{225} &= 2u_{h1} + 2z_{97}\, z_{200} + 2z_{98}\, z_{215} + 2z_{99}\, z_{212} - 2\dot{x}_l \\
z_{226} &= z_3\, z_6\, z_7\, \dot{\psi}_{h1} + z_4\, z_6\, z_9\, \dot{\theta}_{h1} + z_7\, z_8\, z_9\, \dot{\varphi}_{h1} - z_3\, z_6\, \dot{\varphi}_{h1} - z_8\, z_9\, \dot{\psi}_{h1} \\
z_{227} &= z_{127}\, z_{72} + z_{97}\, z_5\, z_{72} + z_{98}\, z_{10}\, z_{72} + z_{99}\, z_{11}\, z_{72} \\
&\quad + 2z_{97}\, z_4\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68}))\dot{\theta}_{h1} \\
&\quad + z_{128}\, (z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77}) \\
&\quad + z_{97}\, z_{12}\, (z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77}) \\
&\quad + z_{98}\, z_{13}\, (z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77}) \\
&\quad + z_{99}\, z_{14}\, (z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77}) + z_{129}\, ((z_{60}\, z_{69} - z_{61}\, z_{68})z_{73} \\
&\qquad + (z_{60}\, z_{70} - z_{62}\, z_{68})z_{74} + z_{61}\, (z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
&\qquad + z_{62}\, (z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78})) + z_{98}\, z_{15}\, ((z_{60}\, z_{69} - z_{61}\, z_{68})z_{73} \\
&\qquad + (z_{60}\, z_{70} - z_{62}\, z_{68})z_{74} + z_{61}\, (z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
&\qquad + z_{62}\, (z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78})) + z_{99}\, z_{16}\, ((z_{60}\, z_{69} - z_{61}\, z_{68})z_{73} \\
&\qquad + (z_{60}\, z_{70} - z_{62}\, z_{68})z_{74} + z_{61}\, (z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
&\qquad + z_{62}\, (z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78})) \\
&\quad - 2z_{60}\, (u_{h1} - \dot{x}_l) - 2(z_{61}\, z_{70} - z_{62}\, z_{69})(v_{h1} - \dot{y}_l) \\
&\quad - 2(z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68}))(w_{h1} - \dot{z}_l) \\
&\quad - 2z_{97}\, z_{60}\, z_{200} - 2z_{98}\, z_{60}\, z_{215} - 2z_{99}\, z_{60}\, z_{212} - 2z_{97}\, (z_{61}\, z_{70} - z_{62}\, z_{69})z_{208} \\
&\quad - 2z_{98}\, (z_{61}\, z_{70} - z_{62}\, z_{69})z_{226} - 2z_{99}\, (z_{61}\, z_{70} - z_{62}\, z_{69})z_{216} \\
&\quad - 2z_{98}\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68}))z_{210} \\
&\quad - 2z_{99}\, (z_{61}\, (z_{60}\, z_{69} - z_{61}\, z_{68}) + z_{62}\, (z_{60}\, z_{70} - z_{62}\, z_{68}))z_{205} \\
&\quad - z_{97}\, z_7\, ((z_{60}\, z_{69} - z_{61}\, z_{68})z_{73} + (z_{60}\, z_{70} - z_{62}\, z_{68})z_{74} \\
&\qquad + z_{61}\, (z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
&\qquad + z_{62}\, (z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}))
\end{aligned}
$$

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\begin{aligned}
z_{228} = {} & z_{127}\, z_{73} + z_{97}\, z_5\, z_{73} + z_{98}\, z_{10}\, z_{73} + z_{99}\, z_{11}\, z_{73} + 2(z_{60}\, z_{70} - z_{62}\, z_{68})(v_{h1} - \dot{y}_l) \\
& + 2(z_{60}\,(z_{60}\, z_{69} - z_{61}\, z_{68}) - z_{62}\,(z_{61}\, z_{70} - z_{62}\, z_{69}))(w_{h1} - \dot{z}_l) \\
& + 2z_{97}\,(z_{60}\, z_{70} - z_{62}\, z_{68})z_{208} \\
& + 2z_{98}\,(z_{60}\, z_{70} - z_{62}\, z_{68})z_{226} + 2z_{99}\,(z_{60}\, z_{70} - z_{62}\, z_{68})z_{216} \\
& + 2z_{98}\,(z_{60}\,(z_{60}\, z_{69} - z_{61}\, z_{68}) - z_{62}\,(z_{61}\, z_{70} - z_{62}\, z_{69}))z_{210} \\
& + 2z_{99}\,(z_{60}\,(z_{60}\, z_{69} - z_{61}\, z_{68}) - z_{62}\,(z_{61}\, z_{70} - z_{62}\, z_{69}))z_{205} \\
& + z_{97}\, z_7\,((z_{60}\, z_{69} - z_{61}\, z_{68})z_{72} + z_{60}\,(z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
& - (z_{61}\, z_{70} - z_{62}\, z_{69})z_{74} - z_{62}\,(z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77})) - 2z_{61}\,(u_{h1} - \dot{x}_l) \\
& - 2z_{97}\, z_4\,(z_{60}\,(z_{60}\, z_{69} - z_{61}\, z_{68}) - z_{62}\,(z_{61}\, z_{70} - z_{62}\, z_{69}))\dot{\theta}_{h1} - 2z_{97}\, z_{61}\, z_{200} \\
& - 2z_{98}\, z_{61}\, z_{215} - 2z_{99}\, z_{61}\, z_{212} - z_{128}\,(z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}) \\
& - z_{97}\, z_{12}\,(z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}) \\
& - z_{98}\, z_{13}\,(z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}) \\
& - z_{99}\, z_{14}\,(z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}) \\
& - z_{129}\,((z_{60}\, z_{69} - z_{61}\, z_{68})z_{72} + z_{60}\,(z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
& \qquad - (z_{61}\, z_{70} - z_{62}\, z_{69})z_{74} - z_{62}\,(z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77})) \\
& - z_{98}\, z_{15}\,((z_{60}\, z_{69} - z_{61}\, z_{68})z_{72} + z_{60}\,(z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
& \qquad - (z_{61}\, z_{70} - z_{62}\, z_{69})z_{74} - z_{62}\,(z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77})) \\
& - z_{99}\, z_{16}\,((z_{60}\, z_{69} - z_{61}\, z_{68})z_{72} + z_{60}\,(z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
& \qquad - (z_{61}\, z_{70} - z_{62}\, z_{69})z_{74} - z_{62}\,(z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77}))
\end{aligned}
$$

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\begin{aligned}
z_{229} = {} & z_{127}\, z_{74} + z_{97}\, z_5\, z_{74} + z_{98}\, z_{10}\, z_{74} + z_{99}\, z_{11}\, z_{74} \\
& + 2(z_{60}\,(z_{60}\, z_{70} - z_{62}\, z_{68}) + z_{61}\,(z_{61}\, z_{70} - z_{62}\, z_{69}))(w_{h1} - \dot{z}_l) \\
& + z_{128}\,(z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
& + z_{97}\, z_{12}\,(z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
& + z_{98}\, z_{13}\,(z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
& + z_{99}\, z_{14}\,(z_{69}\, z_{72} + z_{60}\, z_{77} - z_{68}\, z_{73} - z_{61}\, z_{78}) \\
& + 2z_{98}\,(z_{60}\,(z_{60}\, z_{70} - z_{62}\, z_{68}) + z_{61}\,(z_{61}\, z_{70} - z_{62}\, z_{69}))z_{210} \\
& + 2z_{99}\,(z_{60}\,(z_{60}\, z_{70} - z_{62}\, z_{68}) + z_{61}\,(z_{61}\, z_{70} - z_{62}\, z_{69}))z_{205} \\
& + z_{97}\, z_7\,((z_{60}\, z_{70} - z_{62}\, z_{68})z_{72} + (z_{61}\, z_{70} - z_{62}\, z_{69})z_{73} \\
& \qquad + z_{60}\,(z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}) \\
& \qquad + z_{61}\,(z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77})) \\
& - 2z_{62}\,(u_{h1} - \dot{x}_l) - 2(z_{60}\, z_{69} - z_{61}\, z_{68})(v_{h1} - \dot{y}_l) \\
& - 2z_{97}\, z_4\,(z_{60}\,(z_{60}\, z_{70} - z_{62}\, z_{68}) + z_{61}\,(z_{61}\, z_{70} - z_{62}\, z_{69}))\dot{\theta}_{h1} \\
& - 2z_{97}\, z_{62}\, z_{200} - 2z_{98}\, z_{62}\, z_{215} - 2z_{99}\, z_{62}\, z_{212} - 2z_{97}\,(z_{60}\, z_{69} - z_{61}\, z_{68})z_{208} \\
& - 2z_{98}\,(z_{60}\, z_{69} - z_{61}\, z_{68})z_{226} - 2z_{99}\,(z_{60}\, z_{69} - z_{61}\, z_{68})z_{216} \\
& - z_{129}\,((z_{60}\, z_{70} - z_{62}\, z_{68})z_{72} + (z_{61}\, z_{70} - z_{62}\, z_{69})z_{73} \\
& \qquad + z_{60}\,(z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}) \\
& \qquad + z_{61}\,(z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77})) - z_{98}\, z_{15}\,((z_{60}\, z_{70} - z_{62}\, z_{68})z_{72} \\
& \qquad + (z_{61}\, z_{70} - z_{62}\, z_{69})z_{73} + z_{60}\,(z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}) \\
& \qquad + z_{61}\,(z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77})) - z_{99}\, z_{16}\,((z_{60}\, z_{70} - z_{62}\, z_{68})z_{72} \\
& \qquad + (z_{61}\, z_{70} - z_{62}\, z_{69})z_{73} + z_{60}\,(z_{70}\, z_{72} + z_{60}\, z_{79} - z_{68}\, z_{74} - z_{62}\, z_{78}) \\
& \qquad + z_{61}\,(z_{70}\, z_{73} + z_{61}\, z_{79} - z_{69}\, z_{74} - z_{62}\, z_{77}))
\end{aligned}
$$

$$
\begin{aligned}
z_{230} &= 2z_{98}\, z_{11}\,(u_{h1} - \dot{x}_l) + 2z_{98}\, z_{14}\,(v_{h1} - \dot{y}_l) + 2z_{98}\, z_{16}\,(w_{h1} - \dot{z}_l) + 2z_{99}\, z_{132}\,(v_{h1} - \dot{y}_l) \\
&\quad + 2z_{99}\, z_{133}\,(u_{h1} - \dot{x}_l) + 2z_{98}\, z_{127}\, z_{212} + 2z_{98}\, z_{128}\, z_{216} + 2z_{98}\, z_{129}\, z_{205} \\
&\quad + 2z_{99}\, z_{127}\, z_{219} + 2z_{99}\, z_{128}\, z_{213} - 2z_{99}\, z_{15}\,(w_{h1} - \dot{z}_l) - 2z_{99}\, z_{129}\, z_{210} \\
z_{231} &= 2v_{h1} + 2z_{97}\, z_{208} + 2z_{98}\, z_{226} + 2z_{99}\, z_{216} - 2\dot{y}_l \\
z_{232} &= 2w_{h1} + 2z_{98}\, z_{210} + 2z_{99}\, z_{205} - 2\dot{z}_l - 2z_{97}\, z_4\, \dot{\theta}_{h1} \\
z_{233} &= u_{h1}\, z_{225} + u_l\, z_{227} + v_l\, z_{228} + w_l\, z_{229} + v_{h1}\, z_{231} \\
&\quad + w_{h1}\, z_{232} + p_{h1}\, z_{230} + q_{h1}\, z_{224} + r_{h1}\, z_{221} \\
z_{234} &= -z_{19}\, z_{23}\, \dot{\theta}_{h2} - z_{20}\, z_{25}\, \dot{\psi}_{h2} \\
z_{235} &= \sin(\theta_{h2}) \\
z_{236} &= (z_{22}\, z_{39}\, \dot{\varphi}_{h2} - z_{24}\, z_{235}\, \dot{\theta}_{h2})/z_{39}^2 \\
z_{237} &= z_{19}\, z_{23}\, \dot{\psi}_{h2} + z_{20}\, z_{25}\, \dot{\theta}_{h2} \\
z_{238} &= z_{20}\, z_{22}\, \dot{\theta}_{h2} + z_{23}\, z_{24}\, \dot{\varphi}_{h2} \\
z_{239} &= -z_{20}\, z_{22}\, \dot{\varphi}_{h2} - z_{23}\, z_{24}\, \dot{\theta}_{h2} \\
z_{240} &= z_{24}\, \dot{\theta}_{h2}/z_{39}^2 - z_{22}\, z_{42}\, \dot{\varphi}_{h2} \\
z_{241} &= z_{19}\, z_{20}\, \dot{\theta}_{h2} - z_{23}\, z_{25}\, \dot{\psi}_{h2} \\
z_{242} &= z_{19}\, z_{20}\, \dot{\psi}_{h2} - z_{23}\, z_{25}\, \dot{\theta}_{h2} \\
z_{243} &= z_{20}\, z_{24}\, \dot{\theta}_{h2} - z_{22}\, z_{23}\, \dot{\varphi}_{h2} \\
z_{244} &= z_{20}\, z_{24}\, \dot{\varphi}_{h2} - z_{22}\, z_{23}\, \dot{\theta}_{h2} \\
z_{245} &= z_{19}\, z_{20}\, z_{24}\, \dot{\varphi}_{h2} - z_{19}\, z_{22}\, z_{23}\, \dot{\theta}_{h2} - z_{20}\, z_{22}\, z_{25}\, \dot{\psi}_{h2} \\
z_{246} &= z_{19}\, z_{22}\, \dot{\psi}_{h2} + z_{24}\, z_{25}\, \dot{\varphi}_{h2} + z_{19}\, z_{20}\, z_{24}\, \dot{\theta}_{h2} - z_{19}\, z_{22}\, z_{23}\, \dot{\varphi}_{h2} - z_{23}\, z_{24}\, z_{25}\, \dot{\psi}_{h2} \\
z_{247} &= z_{19}\, z_{22}\, \dot{\varphi}_{h2} + z_{24}\, z_{25}\, \dot{\psi}_{h2} - z_{19}\, z_{22}\, z_{23}\, \dot{\psi}_{h2} - z_{20}\, z_{22}\, z_{25}\, \dot{\theta}_{h2} - z_{23}\, z_{24}\, z_{25}\, \dot{\varphi}_{h2} \\
z_{248} &= z_{19}\, z_{20}\, z_{22}\, \dot{\psi}_{h2} + z_{20}\, z_{24}\, z_{25}\, \dot{\varphi}_{h2} - z_{22}\, z_{23}\, z_{25}\, \dot{\theta}_{h2} \\
z_{249} &= z_{22}\, z_{25}\, \dot{\varphi}_{h2} + z_{19}\, z_{20}\, z_{22}\, \dot{\theta}_{h2} + z_{19}\, z_{23}\, z_{24}\, \dot{\varphi}_{h2} - z_{19}\, z_{24}\, \dot{\psi}_{h2} - z_{22}\, z_{23}\, z_{25}\, \dot{\psi}_{h2} \\
z_{250} &= z_{22}\, z_{25}\, \dot{\psi}_{h2} + z_{19}\, z_{23}\, z_{24}\, \dot{\psi}_{h2} + z_{20}\, z_{24}\, z_{25}\, \dot{\theta}_{h2} - z_{19}\, z_{24}\, \dot{\varphi}_{h2} - z_{22}\, z_{23}\, z_{25}\, \dot{\varphi}_{h2} \\
z_{251} &= -z_{19}\, z_{20}\, z_{22}\, \dot{\varphi}_{h2} - z_{19}\, z_{23}\, z_{24}\, \dot{\theta}_{h2} - z_{20}\, z_{24}\, z_{25}\, \dot{\psi}_{h2} \\
z_{252} &= z_{19}\, z_{24}\, \dot{\varphi}_{h2} + z_{22}\, z_{23}\, z_{25}\, \dot{\varphi}_{h2} - z_{22}\, z_{25}\, \dot{\psi}_{h2} - z_{19}\, z_{23}\, z_{24}\, \dot{\psi}_{h2} - z_{20}\, z_{24}\, z_{25}\, \dot{\theta}_{h2} \\
z_{253} &= z_{19}\, z_{24}\, \dot{\psi}_{h2} + z_{22}\, z_{23}\, z_{25}\, \dot{\psi}_{h2} - z_{22}\, z_{25}\, \dot{\varphi}_{h2} - z_{19}\, z_{20}\, z_{22}\, \dot{\theta}_{h2} - z_{19}\, z_{23}\, z_{24}\, \dot{\varphi}_{h2} \\
z_{254} &= z_{19}\, z_{20}\, z_{24}\, \dot{\psi}_{h2} - z_{20}\, z_{22}\, z_{25}\, \dot{\varphi}_{h2} - z_{23}\, z_{24}\, z_{25}\, \dot{\theta}_{h2}
\end{aligned}
$$

$$
\begin{aligned}
z_{255} &= 2z_{97}\,z_{20}\,z_{24}\,z_{143}\,\dot{\varphi}_{h2} + 2z_{97}\,z_{20}\,z_{22}\,(w_{h2} - \dot{z}_l) \\
&\quad + 2z_{97}\,(z_{21}\,z_{41} + z_{22}\,z_{150})(v_{h2} - \dot{y}_l) + 2z_{98}\,(z_{22}\,z_{153} + z_{32}\,z_{44})(w_{h2} - \dot{z}_l) \\
&\quad + 2z_{97}\,(z_{22}\,z_{144} - z_{28}\,z_{41})(u_{h2} - \dot{x}_l) + 2z_{99}\,(z_{22}\,z_{154} - z_{31}\,z_{44})(w_{h2} - \dot{z}_l) \\
&\quad + 2z_{98}\,z_{143}\,(z_{24}\,z_{153}\,\dot{\varphi}_{h2} + z_{22}\,z_{238} + z_{32}\,z_{240} + z_{44}\,z_{239}) \\
&\quad + 2z_{97}\,z_{141}\,(z_{24}\,z_{144}\,\dot{\varphi}_{h2} + z_{22}\,z_{241} + z_{28}\,z_{236} - z_{41}\,z_{242}) \\
&\quad + 2z_{99}\,z_{143}\,(z_{24}\,z_{154}\,\dot{\varphi}_{h2} + z_{22}\,z_{243} - z_{31}\,z_{240} - z_{44}\,z_{244}) \\
&\quad + 2z_{98}\,z_{141}\,(z_{27}\,z_{240} + z_{41}\,z_{247} + z_{44}\,z_{246} - z_{24}\,z_{145}\,\dot{\varphi}_{h2} - z_{22}\,z_{245} - z_{146}\,z_{236}) \\
&\quad + 2z_{99}\,z_{141}\,(z_{41}\,z_{252} + z_{44}\,z_{253} + z_{147}\,z_{240} - z_{24}\,z_{149}\,\dot{\varphi}_{h2} - z_{22}\,z_{251} - z_{148}\,z_{236}) \\
&\quad - 2z_{97}\,z_{22}\,z_{23}\,z_{143}\,\dot{\theta}_{h2} - 2z_{98}\,(z_{22}\,z_{145} - z_{27}\,z_{44} - z_{41}\,z_{146})(u_{h2} - \dot{x}_l) \\
&\quad - 2z_{98}\,(z_{22}\,z_{151} - z_{26}\,z_{41} - z_{30}\,z_{44})(v_{h2} - \dot{y}_l) \\
&\quad - 2z_{99}\,(z_{22}\,z_{149} - z_{41}\,z_{148} - z_{44}\,z_{147})(u_{h2} - \dot{x}_l) \\
&\quad - 2z_{99}\,(z_{22}\,z_{152} - z_{27}\,z_{41} - z_{44}\,z_{146})(v_{h2} - \dot{y}_l) \\
&\quad - 2z_{97}\,z_{142}\,(z_{21}\,z_{236} - z_{24}\,z_{150}\,\dot{\varphi}_{h2} - z_{22}\,z_{237} - z_{41}\,z_{234}) \\
&\quad - 2z_{98}\,z_{142}\,(z_{24}\,z_{151}\,\dot{\varphi}_{h2} + z_{22}\,z_{248} + z_{26}\,z_{236} - z_{30}\,z_{240} - z_{41}\,z_{249} - z_{44}\,z_{250}) \\
&\quad - 2z_{99}\,z_{142}\,(z_{24}\,z_{152}\,\dot{\varphi}_{h2} + z_{22}\,z_{254} + z_{27}\,z_{236} - z_{41}\,z_{246} - z_{44}\,z_{247} - z_{146}\,z_{240})
\end{aligned}
$$

$$
z_{256} = (z_{22}\,z_{235}\,\dot{\theta}_{h2} + z_{24}\,z_{39}\,\dot{\varphi}_{h2})/z_{39}^2
$$

$$
z_{257} = z_{24}\,z_{42}\,\dot{\varphi}_{h2} + z_{22}\,\dot{\theta}_{h2}/z_{39}^2
$$

$$
\begin{aligned}
z_{258} &= 2z_{97}\,z_{20}\,z_{22}\,z_{143}\,\dot{\varphi}_{h2} + 2z_{97}\,z_{23}\,z_{24}\,z_{143}\,\dot{\theta}_{h2} + 2z_{97}\,(z_{21}\,z_{40} - z_{24}\,z_{150})(v_{h2} - \dot{y}_l) \\
&\quad + 2z_{98}\,(z_{24}\,z_{145} + z_{27}\,z_{43} + z_{40}\,z_{146})(u_{h2} - \dot{x}_l) \\
&\quad + 2z_{98}\,(z_{24}\,z_{151} + z_{26}\,z_{40} + z_{30}\,z_{43})(v_{h2} - \dot{y}_l) \\
&\quad + 2z_{99}\,(z_{24}\,z_{149} + z_{40}\,z_{148} + z_{43}\,z_{147})(u_{h2} - \dot{x}_l) \\
&\quad + 2z_{99}\,(z_{24}\,z_{152} + z_{27}\,z_{40} + z_{43}\,z_{146})(v_{h2} - \dot{y}_l) \\
&\quad + 2z_{97}\,z_{141}\,(z_{22}\,z_{144}\,\dot{\varphi}_{h2} - z_{24}\,z_{241} - z_{28}\,z_{256} - z_{40}\,z_{242}) \\
&\quad + 2z_{99}\,z_{143}\,(z_{22}\,z_{154}\,\dot{\varphi}_{h2} - z_{24}\,z_{243} - z_{31}\,z_{257} - z_{43}\,z_{244}) \\
&\quad - 2z_{97}\,z_{20}\,z_{24}\,(w_{h2} - \dot{z}_l) - 2z_{97}\,(z_{24}\,z_{144} + z_{28}\,z_{40})(u_{h2} - \dot{x}_l) \\
&\quad - 2z_{99}\,(z_{24}\,z_{154} + z_{31}\,z_{43})(w_{h2} - \dot{z}_l) - 2z_{98}\,(z_{24}\,z_{153} - z_{32}\,z_{43})(w_{h2} - \dot{z}_l) \\
&\quad - 2z_{97}\,z_{142}\,(z_{24}\,z_{237} - z_{22}\,z_{150}\,\dot{\varphi}_{h2} - z_{21}\,z_{256} - z_{40}\,z_{234}) \\
&\quad - 2z_{98}\,z_{143}\,(z_{24}\,z_{238} - z_{22}\,z_{153}\,\dot{\varphi}_{h2} - z_{32}\,z_{257} - z_{43}\,z_{239}) \\
&\quad - 2z_{98}\,z_{141}\,(z_{22}\,z_{145}\,\dot{\varphi}_{h2} - z_{24}\,z_{245} - z_{27}\,z_{257} - z_{40}\,z_{247} - z_{43}\,z_{246} - z_{146}\,z_{256}) \\
&\quad - 2z_{98}\,z_{142}\,(z_{22}\,z_{151}\,\dot{\varphi}_{h2} - z_{24}\,z_{248} - z_{26}\,z_{256} - z_{30}\,z_{257} - z_{40}\,z_{249} - z_{43}\,z_{250}) \\
&\quad - 2z_{99}\,z_{141}\,(z_{22}\,z_{149}\,\dot{\varphi}_{h2} - z_{24}\,z_{251} - z_{40}\,z_{252} - z_{43}\,z_{253} - z_{147}\,z_{257} - z_{148}\,z_{256}) \\
&\quad - 2z_{99}\,z_{142}\,(z_{22}\,z_{152}\,\dot{\varphi}_{h2} - z_{24}\,z_{254} - z_{27}\,z_{256} - z_{40}\,z_{246} - z_{43}\,z_{247} - z_{146}\,z_{257})
\end{aligned}
$$

$$
z_{259} = 2u_{h2} + 2z_{97}\,z_{234} + 2z_{98}\,z_{249} + 2z_{99}\,z_{246} - 2\dot{x}_l
$$

$$
z_{260} = z_{19}\,z_{22}\,z_{23}\,\dot{\psi}_{h2} + z_{20}\,z_{22}\,z_{25}\,\dot{\theta}_{h2} + z_{23}\,z_{24}\,z_{25}\,\dot{\varphi}_{h2} - z_{19}\,z_{22}\,\dot{\varphi}_{h2} - z_{24}\,z_{25}\,\dot{\psi}_{h2}
$$

$$
\begin{aligned}
z_{261} &= z_{141}\,z_{72} + z_{97}\,z_{21}\,z_{72} + z_{98}\,z_{26}\,z_{72} + z_{99}\,z_{27}\,z_{72} \\
&\quad + 2z_{97}\,z_{20}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68}))\dot{\theta}_{h2} \\
&\quad + z_{142}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77}) \\
&\quad + z_{97}\,z_{28}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77}) \\
&\quad + z_{98}\,z_{29}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77}) \\
&\quad + z_{99}\,z_{30}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77}) + z_{143}\,((z_{60}\,z_{69} - z_{61}\,z_{68})z_{73} \\
&\qquad\qquad + (z_{60}\,z_{70} - z_{62}\,z_{68})z_{74} + z_{61}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\qquad + z_{62}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78})) + z_{98}\,z_{31}\,((z_{60}\,z_{69} - z_{61}\,z_{68})z_{73} \\
&\qquad\qquad + (z_{60}\,z_{70} - z_{62}\,z_{68})z_{74} + z_{61}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\qquad + z_{62}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78})) + z_{99}\,z_{32}\,((z_{60}\,z_{69} - z_{61}\,z_{68})z_{73} \\
&\qquad\qquad + (z_{60}\,z_{70} - z_{62}\,z_{68})z_{74} + z_{61}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\qquad\qquad + z_{62}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78})) \\
&\quad - 2z_{60}\,(u_{h2} - \dot{x}_l) - 2(z_{61}\,z_{70} - z_{62}\,z_{69})(v_{h2} - \dot{y}_l) \\
&\quad - 2(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68}))(w_{h2} - \dot{z}_l) \\
&\quad - 2z_{97}\,z_{60}\,z_{234} - 2z_{98}\,z_{60}\,z_{249} - 2z_{99}\,z_{60}\,z_{246} - 2z_{97}\,(z_{61}\,z_{70} - z_{62}\,z_{69})z_{242} \\
&\quad - 2z_{98}\,(z_{61}\,z_{70} - z_{62}\,z_{69})z_{260} - 2z_{99}\,(z_{61}\,z_{70} - z_{62}\,z_{69})z_{250} \\
&\quad - 2z_{98}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68}))z_{244} \\
&\quad - 2z_{99}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68}))z_{239} \\
&\quad - z_{97}\,z_{23}\,((z_{60}\,z_{69} - z_{61}\,z_{68})z_{73} + (z_{60}\,z_{70} - z_{62}\,z_{68})z_{74} \\
&\qquad\qquad + z_{61}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\qquad\qquad + z_{62}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}))
\end{aligned}
$$

$$
\begin{aligned}
z_{262} &= z_{141}\,z_{73} + z_{97}\,z_{21}\,z_{73} + z_{98}\,z_{26}\,z_{73} + z_{99}\,z_{27}\,z_{73} + 2(z_{60}\,z_{70} - z_{62}\,z_{68})(v_{h2} - \dot{y}_l) \\
&\quad + 2(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))(w_{h2} - \dot{z}_l) \\
&\quad + 2z_{97}\,(z_{60}\,z_{70} - z_{62}\,z_{68})z_{242} \\
&\quad + 2z_{98}\,(z_{60}\,z_{70} - z_{62}\,z_{68})z_{260} + 2z_{99}\,(z_{60}\,z_{70} - z_{62}\,z_{68})z_{250} \\
&\quad + 2z_{98}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))z_{244} \\
&\quad + 2z_{99}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))z_{239} \\
&\quad + z_{97}\,z_{23}\,((z_{60}\,z_{69} - z_{61}\,z_{68})z_{72} + z_{60}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\quad - (z_{61}\,z_{70} - z_{62}\,z_{69})z_{74} - z_{62}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77})) - 2z_{61}\,(u_{h2} - \dot{x}_l) \\
&\quad - 2z_{97}\,z_{20}\,(z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))\dot{\theta}_{h2} - 2z_{97}\,z_{61}\,z_{234} \\
&\quad - 2z_{98}\,z_{61}\,z_{249} - 2z_{99}\,z_{61}\,z_{246} - z_{142}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}) \\
&\quad - z_{97}\,z_{28}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}) \\
&\quad - z_{98}\,z_{29}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}) \\
&\quad - z_{99}\,z_{30}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}) \\
&\quad - z_{143}\,((z_{60}\,z_{69} - z_{61}\,z_{68})z_{72} + z_{60}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\qquad\qquad - (z_{61}\,z_{70} - z_{62}\,z_{69})z_{74} - z_{62}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77})) \\
&\quad - z_{98}\,z_{31}\,((z_{60}\,z_{69} - z_{61}\,z_{68})z_{72} + z_{60}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\qquad\qquad - (z_{61}\,z_{70} - z_{62}\,z_{69})z_{74} - z_{62}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77})) \\
&\quad - z_{99}\,z_{32}\,((z_{60}\,z_{69} - z_{61}\,z_{68})z_{72} + z_{60}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\qquad\qquad - (z_{61}\,z_{70} - z_{62}\,z_{69})z_{74} - z_{62}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77}))
\end{aligned}
$$

$$
\begin{aligned}
z_{263} &= z_{141}\,z_{74} + z_{97}\,z_{21}\,z_{74} + z_{98}\,z_{26}\,z_{74} + z_{99}\,z_{27}\,z_{74} \\
&\quad + 2(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))(w_{h2} - \dot{z}_l) \\
&\quad + z_{142}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\quad + z_{97}\,z_{28}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\quad + z_{98}\,z_{29}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\quad + z_{99}\,z_{30}\,(z_{69}\,z_{72} + z_{60}\,z_{77} - z_{68}\,z_{73} - z_{61}\,z_{78}) \\
&\quad + 2z_{98}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))z_{244} \\
&\quad + 2z_{99}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))z_{239} \\
&\quad + z_{97}\,z_{23}\,((z_{60}\,z_{70} - z_{62}\,z_{68})z_{72} + (z_{61}\,z_{70} - z_{62}\,z_{69})z_{73} \\
&\qquad\qquad + z_{60}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}) \\
&\qquad\qquad + z_{61}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77})) \\
&\quad - 2z_{62}\,(u_{h2} - \dot{x}_l) - 2(z_{60}\,z_{69} - z_{61}\,z_{68})(v_{h2} - \dot{y}_l) \\
&\quad - 2z_{97}\,z_{20}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))\dot{\theta}_{h2} \\
&\quad - 2z_{97}\,z_{62}\,z_{234} - 2z_{98}\,z_{62}\,z_{249} - 2z_{99}\,z_{62}\,z_{246} - 2z_{97}\,(z_{60}\,z_{69} - z_{61}\,z_{68})z_{242} \\
&\quad - 2z_{98}\,(z_{60}\,z_{69} - z_{61}\,z_{68})z_{260} - 2z_{99}\,(z_{60}\,z_{69} - z_{61}\,z_{68})z_{250} \\
&\quad - z_{143}\,((z_{60}\,z_{70} - z_{62}\,z_{68})z_{72} + (z_{61}\,z_{70} - z_{62}\,z_{69})z_{73} \\
&\qquad\qquad + z_{60}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}) \\
&\qquad\qquad + z_{61}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77})) - z_{98}\,z_{31}\,((z_{60}\,z_{70} - z_{62}\,z_{68})z_{72} \\
&\qquad\qquad + (z_{61}\,z_{70} - z_{62}\,z_{69})z_{73} + z_{60}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}) \\
&\qquad\qquad + z_{61}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77})) - z_{99}\,z_{32}\,((z_{60}\,z_{70} - z_{62}\,z_{68})z_{72} \\
&\qquad\qquad + (z_{61}\,z_{70} - z_{62}\,z_{69})z_{73} + z_{60}\,(z_{70}\,z_{72} + z_{60}\,z_{79} - z_{68}\,z_{74} - z_{62}\,z_{78}) \\
&\qquad\qquad + z_{61}\,(z_{70}\,z_{73} + z_{61}\,z_{79} - z_{69}\,z_{74} - z_{62}\,z_{77}))
\end{aligned}
$$

$$
\begin{aligned}
z_{264} &= 2z_{98}\,z_{27}\,(u_{h2} - \dot{x}_l) + 2z_{98}\,z_{30}\,(v_{h2} - \dot{y}_l) + 2z_{98}\,z_{32}\,(w_{h2} - \dot{z}_l) + 2z_{99}\,z_{146}\,(v_{h2} - \dot{y}_l) \\
&\quad + 2z_{99}\,z_{147}\,(u_{h2} - \dot{x}_l) + 2z_{98}\,z_{141}\,z_{246} + 2z_{98}\,z_{142}\,z_{250} + 2z_{98}\,z_{143}\,z_{239} \\
&\quad + 2z_{99}\,z_{141}\,z_{253} + 2z_{99}\,z_{142}\,z_{247} - 2z_{99}\,z_{31}\,(w_{h2} - \dot{z}_l) - 2z_{99}\,z_{143}\,z_{244}
\end{aligned}
$$

$$
z_{265} = 2v_{h2} + 2z_{97}\,z_{242} + 2z_{98}\,z_{260} + 2z_{99}\,z_{250} - 2\dot{y}_l
$$

$$
z_{266} = 2w_{h2} + 2z_{98}\,z_{244} + 2z_{99}\,z_{239} - 2\dot{z}_l - 2z_{97}\,z_{20}\,\dot{\theta}_{h2}
$$

$$
\begin{aligned}
z_{267} &= p_{h2}\,z_{264} + q_{h2}\,z_{258} + r_{h2}\,z_{255} + u_l\,z_{261} + v_l\,z_{262} \\
&\quad + w_l\,z_{263} + u_{h2}\,z_{259} + v_{h2}\,z_{265} + w_{h2}\,z_{266}
\end{aligned}
$$

$$
z_{268} = (z_{160}\,z_{267} - z_{169}\,z_{233})/z_{173}
$$

$$
z_{269} = (z_{158}\,z_{267} - z_{167}\,z_{233})/z_{173}
$$

$$
\begin{aligned}
z_{272} &= -z_{176}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad - z_{189}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{275} &= -z_{179}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad - z_{192}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{278} &= -z_{180}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad - z_{193}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{281} &= -z_{178}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad - z_{191}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{284} &= -z_{175}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad - z_{188}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{287} &= -z_{174}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad - z_{187}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{290} &= z_{183}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad + z_{196}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{293} &= z_{185}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad + z_{198}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{296} &= z_{186}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad + z_{199}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{299} &= z_{184}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad + z_{197}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{302} &= z_{182}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad + z_{195}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{305} &= z_{181}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68})) \\
&\quad + z_{194}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69}))
\end{aligned}
$$

$$
\begin{aligned}
z_{308} &= z_{62}\,(z_{61}\,z_{70} - z_{62}\,z_{69}) + z_{190}\,(z_{60}\,(z_{60}\,z_{70} - z_{62}\,z_{68}) + z_{61}\,(z_{61}\,z_{70} - z_{62}\,z_{69})) \\
&\quad - z_{60}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) - z_{177}\,(z_{61}\,(z_{60}\,z_{69} - z_{61}\,z_{68}) + z_{62}\,(z_{60}\,z_{70} - z_{62}\,z_{68}))
\end{aligned}
$$

$$
\begin{aligned}
z_{309} &= F^{MR}_{h1,3} z_{11} + F^{TR}_{h1,2} z_{10} + z_{125}\,z_5\,z_7 + z_{124}\,(z_5\,z_7 - z_{10}\,z_{15} - z_{11}\,z_{16}) \\
&\quad - z_{126}\,z_{272} - z_{125}\,z_{10}\,z_{15} - z_{125}\,z_{11}\,z_{16}
\end{aligned}
$$

$$
\begin{aligned}
z_{310} &= F^{MR}_{h1,3} z_{14} + F^{TR}_{h1,2} z_{13} + z_{125}\,z_7\,z_{12} + z_{124}\,(z_7\,z_{12} - z_{13}\,z_{15} - z_{14}\,z_{16}) \\
&\quad - z_{126}\,z_{275} - z_{125}\,z_{13}\,z_{15} - z_{125}\,z_{14}\,z_{16}
\end{aligned}
$$

$$
z_{311} = F^{MR}_{h1,3} z_{16} + F^{TR}_{h1,2} z_{15} - z_{126}\,z_{278} - z_{125}\,z_7^2 - z_{125}\,z_{15}^2 - z_{125}\,z_{16}^2 - z_{124}\,(z_7^{2+} z_{15}^{2+} z_{16}^{2)}
$$

$$
z_{312} = z_{90}\,z_{125}
$$

$$
z_{313} = z_{89}\,z_{125}
$$

$$
z_{314} = T^{MR}_{h1,1} + z_{89}\,F^{MR}_{h1,3} + z_{312}\,z_{15} - z_{96}\,F^{TR}_{h1,2} - z_{126}\,z_{281} - z_{313}\,z_{16} - z_{124}\,(z_{92}\,z_{16} - z_{93}\,z_{15})
$$

$$
z_{315} = z_{88}\,z_{125}
$$

$$
z_{316} = T^{MR}_{h1,2} + T^{TR}_{h1,2} + z_{312}\,z_7 + z_{315}\,z_{16} + z_{124}\,(z_{91}\,z_{16} + z_{93}\,z_7) - z_{88}\,F^{MR}_{h1,3} - z_{126}\,z_{284}
$$

$$
z_{317} = T^{MR}_{h1,3} + z_{94}\,F^{TR}_{h1,2} - z_{126}\,z_{287} - z_{124}\,(z_{91}\,z_{15} + z_{92}\,z_7) - z_{125}\,(z_{88}\,z_{15} + z_{89}\,z_7)
$$

$$
\begin{aligned}
z_{318} &= F^{MR}_{h2,3} z_{27} + F^{TR}_{h2,2} z_{26} + z_{125}\,z_{21}\,z_{23} + z_{124}\,(z_{21}\,z_{23} - z_{26}\,z_{31} - z_{27}\,z_{32}) \\
&\quad - z_{126}\,z_{290} - z_{125}\,z_{26}\,z_{31} - z_{125}\,z_{27}\,z_{32}
\end{aligned}
$$

$$z_{319} = F^{MR}_{h2,3} z_{30} + F^{TR}_{h2,2} z_{29} + z_{125}\, z_{23}\, z_{28} + z_{124}\,(z_{23}\, z_{28} - z_{29}\, z_{31} - z_{30}\, z_{32}) - z_{126}\, z_{293} - z_{125}\, z_{29}\, z_{31} - z_{125}\, z_{30}\, z_{32}$$

$$z_{320} = F^{MR}_{h2,3} z_{32} + F^{TR}_{h2,2} z_{31} - z_{126}\, z_{296} - z_{125}\, z^2_{23} - z_{125}\, z^2_{31} - z_{125}\, z^2_{32} - z_{124}\,(z^{2+}_{23}\, z^{2+}_{31}\, z^{2)}_{32}$$

$$z_{321} = T^{MR}_{h2,1} + z_{89}\, F^{MR}_{h2,3} + z_{312}\, z_{31} - z_{96}\, F^{TR}_{h2,2} - z_{126}\, z_{299} - z_{313}\, z_{32} - z_{124}\,(z_{92}\, z_{32} - z_{93}\, z_{31})$$

$$z_{322} = T^{MR}_{h2,2} + T^{TR}_{h2,2} + z_{312}\, z_{23} + z_{315}\, z_{32} + z_{124}\,(z_{91}\, z_{32} + z_{93}\, z_{23}) - z_{88}\, F^{MR}_{h2,3} - z_{126}\, z_{302}$$

$$z_{323} = T^{MR}_{h2,3} + z_{94}\, F^{TR}_{h2,2} - z_{126}\, z_{305} - z_{124}\,(z_{91}\, z_{31} + z_{92}\, z_{23}) - z_{125}\,(z_{88}\, z_{31} + z_{89}\, z_{23})$$

$$z_{324} = z_{126}\, z_{308}$$

$$z_{325} = I^F_{11}\, p_{h1}$$

$$z_{326} = I^F_{22}\, q_{h1}$$

$$z_{327} = I^F_{33}\, r_{h1}$$

$$z_{328} = p_{h1}\, z_{326} - q_{h1}\, z_{325}$$

$$z_{329} = r_{h1}\, z_{325} - p_{h1}\, z_{327}$$

$$z_{330} = q_{h1}\, z_{327} - r_{h1}\, z_{326}$$

$$z_{331} = I^{MR}_{11}\, p_{h1}$$

$$z_{332} = I^{MR}_{22}\, q_{h1}$$

$$z_{333} = I^{MR}_{33}\, z_{45}$$

$$z_{334} = I^{MR}_{11}\, z_{46}$$

$$z_{335} = I^{MR}_{22}\, z_{47}$$

$$z_{336} = p_{h1}\, z_{332} - q_{h1}\, z_{331}$$

$$z_{337} = z_{45}\, z_{331} - p_{h1}\, z_{333}$$

$$z_{338} = q_{h1}\, z_{333} - z_{45}\, z_{332}$$

$$z_{339} = I^F_{11}\, p_{h2}$$

$$z_{340} = I^F_{22}\, q_{h2}$$

$$z_{341} = I^F_{33}\, r_{h2}$$

$$z_{342} = p_{h2}\, z_{340} - q_{h2}\, z_{339}$$

$$z_{343} = r_{h2}\, z_{339} - p_{h2}\, z_{341}$$

$$z_{344} = q_{h2}\, z_{341} - r_{h2}\, z_{340}$$

$$z_{345} = I^{MR}_{11}\, p_{h2}$$

$$z_{346} = I_{22}^{MR}\, q_{h2}$$

$$z_{347} = I_{33}^{MR}\, z_{48}$$

$$z_{348} = I_{11}^{MR}\, z_{49}$$

$$z_{349} = I_{22}^{MR}\, z_{50}$$

$$z_{350} = p_{h2}\, z_{346} - q_{h2}\, z_{345}$$

$$z_{351} = z_{48}\, z_{345} - p_{h2}\, z_{347}$$

$$z_{352} = q_{h2}\, z_{347} - z_{48}\, z_{346}$$

$$z_{353} = m_F\,(z_{91}\, z_{10} - z_{92}\, z_5) + m_{MR}\,(z_{88}\, z_{10} - z_{89}\, z_5)$$

$$z_{354} = z_{51}\,(z_5\, z_7 - z_{10}\, z_{15} - z_{11}\, z_{16})$$

$$z_{355} = -m_F\,(z_{91}\, z_{11} - z_{93}\, z_5) - m_{MR}\,(z_{88}\, z_{11} - z_{90}\, z_5)$$

$$z_{356} = z_{51}\,(z_5^{2+} z_{10}^{2+} z_{11}^{2)}$$

$$z_{357} = z_{51}\,(z_5\, z_{12} + z_{10}\, z_{13} + z_{11}\, z_{14})$$

$$z_{358} = m_F\,(z_{92}\, z_{11} - z_{93}\, z_{10}) + m_{MR}\,(z_{89}\, z_{11} - z_{90}\, z_{10})$$

$$z_{359} = m_F\,(z_5\, z_{103} + z_{10}\, z_{104} + z_{11}\, z_{105}) + m_{MR}\,(z_5\, z_{100} + z_{10}\, z_{101} + z_{11}\, z_{102})$$

$$z_{360} = m_F\,(z_{91}\, z_{13} - z_{92}\, z_{12}) + m_{MR}\,(z_{88}\, z_{13} - z_{89}\, z_{12})$$

$$z_{361} = z_{51}\,(z_7\, z_{12} - z_{13}\, z_{15} - z_{14}\, z_{16})$$

$$z_{362} = -m_F\,(z_{91}\, z_{14} - z_{93}\, z_{12}) - m_{MR}\,(z_{88}\, z_{14} - z_{90}\, z_{12})$$

$$z_{363} = z_{51}\,(z_{12}^{2+} z_{13}^{2+} z_{14}^{2)}$$

$$z_{364} = m_F\,(z_{92}\, z_{14} - z_{93}\, z_{13}) + m_{MR}\,(z_{89}\, z_{14} - z_{90}\, z_{13})$$

$$z_{365} = m_F\,(z_{12}\, z_{103} + z_{13}\, z_{104} + z_{14}\, z_{105}) + m_{MR}\,(z_{12}\, z_{100} + z_{13}\, z_{101} + z_{14}\, z_{102})$$

$$z_{366} = m_F\,(z_{91}\, z_{15} + z_{92}\, z_7) + m_{MR}\,(z_{88}\, z_{15} + z_{89}\, z_7)$$

$$z_{367} = z_{51}\,(z_7^{2+} z_{15}^{2+} z_{16}^{2)}$$

$$z_{368} = -m_F\,(z_{91}\, z_{16} + z_{93}\, z_7) - m_{MR}\,(z_{88}\, z_{16} + z_{90}\, z_7)$$

$$z_{369} = m_F\,(z_{92}\, z_{16} - z_{93}\, z_{15}) + m_{MR}\,(z_{89}\, z_{16} - z_{90}\, z_{15})$$

$$z_{370} = -m_F\,(z_7\, z_{103} - z_{15}\, z_{104} - z_{16}\, z_{105}) - m_{MR}\,(z_7\, z_{100} - z_{15}\, z_{101} - z_{16}\, z_{102})$$

$$z_{371} = I_{11}^{F} + I_{11}^{MR} + m_F\,(z_{92}^{2+} z_{93}^{2)} + m_{MR}\,(z_{89}^{2+} z_{90}^{2)}$$

$$z_{372} = -m_F\, z_{91}\, z_{93} - m_{MR}\, z_{88}\, z_{90}$$

$$z_{373} = -m_F\, z_{91}\, z_{92} - m_{MR}\, z_{88}\, z_{89}$$

$$z_{374} = z_{330} + z_{338} + m_F\,(z_{92}\,z_{105} - z_{93}\,z_{104}) + m_{MR}\,(z_{89}\,z_{102} - z_{90}\,z_{101}) - z_{334}$$

$$z_{375} = I_{22}^{F} + I_{22}^{MR} + m_F\,(z_{91}^{2+}\,z_{93}^{2)} + m_{MR}\,(z_{88}^{2+}\,z_{90}^{2)}$$

$$z_{376} = -m_F\,z_{92}\,z_{93} - m_{MR}\,z_{89}\,z_{90}$$

$$z_{377} = z_{329} + z_{335} + z_{337} - m_F\,(z_{91}\,z_{105} - z_{93}\,z_{103}) - m_{MR}\,(z_{88}\,z_{102} - z_{90}\,z_{100})$$

$$z_{378} = I_{33}^{F} + I_{33}^{MR} + m_F\,(z_{91}^{2+}\,z_{92}^{2)} + m_{MR}\,(z_{88}^{2+}\,z_{89}^{2)}$$

$$z_{379} = z_{328} + z_{336} + m_F\,(z_{91}\,z_{104} - z_{92}\,z_{103}) + m_{MR}\,(z_{88}\,z_{101} - z_{89}\,z_{100})$$

$$z_{380} = m_F\,(z_{91}\,z_{26} - z_{92}\,z_{21}) + m_{MR}\,(z_{88}\,z_{26} - z_{89}\,z_{21})$$

$$z_{381} = z_{51}\,(z_{21}\,z_{23} - z_{26}\,z_{31} - z_{27}\,z_{32})$$

$$z_{382} = -m_F\,(z_{91}\,z_{27} - z_{93}\,z_{21}) - m_{MR}\,(z_{88}\,z_{27} - z_{90}\,z_{21})$$

$$z_{383} = z_{51}\,(z_{21}^{2+}\,z_{26}^{2+}\,z_{27}^{2)}$$

$$z_{384} = z_{51}\,(z_{21}\,z_{28} + z_{26}\,z_{29} + z_{27}\,z_{30})$$

$$z_{385} = m_F\,(z_{92}\,z_{27} - z_{93}\,z_{26}) + m_{MR}\,(z_{89}\,z_{27} - z_{90}\,z_{26})$$

$$z_{386} = m_F\,(z_{21}\,z_{115} + z_{26}\,z_{116} + z_{27}\,z_{117}) + m_{MR}\,(z_{21}\,z_{112} + z_{26}\,z_{113} + z_{27}\,z_{114})$$

$$z_{387} = m_F\,(z_{91}\,z_{29} - z_{92}\,z_{28}) + m_{MR}\,(z_{88}\,z_{29} - z_{89}\,z_{28})$$

$$z_{388} = z_{51}\,(z_{23}\,z_{28} - z_{29}\,z_{31} - z_{30}\,z_{32})$$

$$z_{389} = -m_F\,(z_{91}\,z_{30} - z_{93}\,z_{28}) - m_{MR}\,(z_{88}\,z_{30} - z_{90}\,z_{28})$$

$$z_{390} = z_{51}\,(z_{28}^{2+}\,z_{29}^{2+}\,z_{30}^{2)}$$

$$z_{391} = m_F\,(z_{92}\,z_{30} - z_{93}\,z_{29}) + m_{MR}\,(z_{89}\,z_{30} - z_{90}\,z_{29})$$

$$z_{392} = m_F\,(z_{28}\,z_{115} + z_{29}\,z_{116} + z_{30}\,z_{117}) + m_{MR}\,(z_{28}\,z_{112} + z_{29}\,z_{113} + z_{30}\,z_{114})$$

$$z_{393} = m_F\,(z_{91}\,z_{31} + z_{92}\,z_{23}) + m_{MR}\,(z_{88}\,z_{31} + z_{89}\,z_{23})$$

$$z_{394} = z_{51}\,(z_{23}^{2+}\,z_{31}^{2+}\,z_{32}^{2)}$$

$$z_{395} = -m_F\,(z_{91}\,z_{32} + z_{93}\,z_{23}) - m_{MR}\,(z_{88}\,z_{32} + z_{90}\,z_{23})$$

$$z_{396} = m_F\,(z_{92}\,z_{32} - z_{93}\,z_{31}) + m_{MR}\,(z_{89}\,z_{32} - z_{90}\,z_{31})$$

$$z_{397} = -m_F\,(z_{23}\,z_{115} - z_{31}\,z_{116} - z_{32}\,z_{117}) - m_{MR}\,(z_{23}\,z_{112} - z_{31}\,z_{113} - z_{32}\,z_{114})$$

$$z_{398} = z_{344} + z_{352} + m_F\,(z_{92}\,z_{117} - z_{93}\,z_{116}) + m_{MR}\,(z_{89}\,z_{114} - z_{90}\,z_{113}) - z_{348}$$

$$z_{399} = z_{343} + z_{349} + z_{351} - m_F\,(z_{91}\,z_{117} - z_{93}\,z_{115}) - m_{MR}\,(z_{88}\,z_{114} - z_{90}\,z_{112})$$

$$z_{400} = z_{342} + z_{350} + m_F\,(z_{91}\,z_{116} - z_{92}\,z_{115}) + m_{MR}\,(z_{88}\,z_{113} - z_{89}\,z_{112})$$

$$z_{401} = l_{rp}\,(z_{60}\,z_{61} + z_{81}\,z_{82} + z_{84}\,z_{86})$$

$$z_{402} = l_p\,(z_{61}^{2+}\, z_{82}^{2+}\, z_{86}^{2)}$$

$$z_{403} = l_p\,(z_{61}\, z_{62} + z_{80}\, z_{82} + z_{85}\, z_{86})$$

$$z_{404} = l_p\,(z_{61}\, z_{75} + z_{82}\, z_{83} + z_{86}\, z_{87})$$

$$z_{405} = l_p\,(z_{60}^{2+}\, z_{81}^{2+}\, z_{84}^{2)}$$

$$z_{406} = l_p\,(z_{60}\, z_{62} + z_{80}\, z_{81} + z_{84}\, z_{85})$$

$$z_{407} = l_p\,(z_{60}\, z_{75} + z_{81}\, z_{83} + z_{84}\, z_{87})$$

$$z_{408} = l_p\,(z_{62}^{2+}\, z_{80}^{2+}\, z_{85}^{2)}$$

$$z_{409} = l_p\,(z_{62}\, z_{75} + z_{80}\, z_{83} + z_{85}\, z_{87})$$

$$z_{410} = z_{189}\, z_{406} - z_{176}\, z_{405}$$

$$z_{411} = z_{189}\, z_{403} - z_{176}\, z_{401}$$

$$z_{412} = z_{189}\, z_{408} - z_{176}\, z_{406}$$

$$z_{413} = z_{359} + z_{189}\, z_{409} - z_{176}\, z_{407}$$

$$z_{414} = z_{356} + z_{189}\, z_{412} - z_{176}\, z_{410}$$

$$z_{415} = z_{357} + z_{192}\, z_{412} - z_{179}\, z_{410}$$

$$z_{416} = z_{193}\, z_{412} - z_{354} - z_{180}\, z_{410}$$

$$z_{417} = z_{358} + z_{191}\, z_{412} - z_{178}\, z_{410}$$

$$z_{418} = z_{355} + z_{188}\, z_{412} - z_{175}\, z_{410}$$

$$z_{419} = z_{353} + z_{187}\, z_{412} - z_{174}\, z_{410}$$

$$z_{420} = z_{183}\, z_{410} - z_{196}\, z_{412}$$

$$z_{421} = z_{185}\, z_{410} - z_{198}\, z_{412}$$

$$z_{422} = z_{186}\, z_{410} - z_{199}\, z_{412}$$

$$z_{423} = z_{184}\, z_{410} - z_{197}\, z_{412}$$

$$z_{424} = z_{182}\, z_{410} - z_{195}\, z_{412}$$

$$z_{425} = z_{181}\, z_{410} - z_{194}\, z_{412}$$

$$z_{426} = z_{411} - z_{177}\, z_{410} - z_{190}\, z_{412}$$

$$z_{427} = z_{413} + z_{410}\, z_{268} - z_{412}\, z_{269}$$

$$z_{428} = z_{192}\, z_{406} - z_{179}\, z_{405}$$

$$z_{429} = z_{192}\, z_{403} - z_{179}\, z_{401}$$

$$z_{430} = z_{192}\, z_{408} - z_{179}\, z_{406}$$

$$z_{431} = z_{365} + z_{192}\, z_{409} - z_{179}\, z_{407}$$

$$z_{432} = z_{357} + z_{189}\, z_{430} - z_{176}\, z_{428}$$

$$z_{433} = z_{363} + z_{192}\, z_{430} - z_{179}\, z_{428}$$

$$z_{434} = z_{193}\, z_{430} - z_{361} - z_{180}\, z_{428}$$

$$z_{435} = z_{364} + z_{191}\, z_{430} - z_{178}\, z_{428}$$

$$z_{436} = z_{362} + z_{188}\, z_{430} - z_{175}\, z_{428}$$

$$z_{437} = z_{360} + z_{187}\, z_{430} - z_{174}\, z_{428}$$

$$z_{438} = z_{183}\, z_{428} - z_{196}\, z_{430}$$

$$z_{439} = z_{185}\, z_{428} - z_{198}\, z_{430}$$

$$z_{440} = z_{186}\, z_{428} - z_{199}\, z_{430}$$

$$z_{441} = z_{184}\, z_{428} - z_{197}\, z_{430}$$

$$z_{442} = z_{182}\, z_{428} - z_{195}\, z_{430}$$

$$z_{443} = z_{181}\, z_{428} - z_{194}\, z_{430}$$

$$z_{444} = z_{429} - z_{177}\, z_{428} - z_{190}\, z_{430}$$

$$z_{445} = z_{431} + z_{428}\, z_{268} - z_{430}\, z_{269}$$

$$z_{446} = z_{193}\, z_{406} - z_{180}\, z_{405}$$

$$z_{447} = z_{193}\, z_{403} - z_{180}\, z_{401}$$

$$z_{448} = z_{193}\, z_{408} - z_{180}\, z_{406}$$

$$z_{449} = z_{370} + z_{193}\, z_{409} - z_{180}\, z_{407}$$

$$z_{450} = z_{189}\, z_{448} - z_{354} - z_{176}\, z_{446}$$

$$z_{451} = z_{192}\, z_{448} - z_{361} - z_{179}\, z_{446}$$

$$z_{452} = z_{367} + z_{193}\, z_{448} - z_{180}\, z_{446}$$

$$z_{453} = z_{369} + z_{191}\, z_{448} - z_{178}\, z_{446}$$

$$z_{454} = z_{368} + z_{188}\, z_{448} - z_{175}\, z_{446}$$

$$z_{455} = z_{366} + z_{187}\, z_{448} - z_{174}\, z_{446}$$

$$z_{456} = z_{183}\, z_{446} - z_{196}\, z_{448}$$

$$z_{457} = z_{185}\, z_{446} - z_{198}\, z_{448}$$

$$z_{458} = z_{186}\, z_{446} - z_{199}\, z_{448}$$

$$z_{459} = z_{184}\, z_{446} - z_{197}\, z_{448}$$

$$z_{460} = z_{182}\, z_{446} - z_{195}\, z_{448}$$

$$z_{461} = z_{181}\, z_{446} - z_{194}\, z_{448}$$

$$z_{462} = z_{447} - z_{177}\, z_{446} - z_{190}\, z_{448}$$

$$z_{463} = z_{449} + z_{446}\, z_{268} - z_{448}\, z_{269}$$

$$z_{464} = z_{191}\, z_{406} - z_{178}\, z_{405}$$

$$z_{465} = z_{191}\, z_{403} - z_{178}\, z_{401}$$

$$z_{466} = z_{191}\, z_{408} - z_{178}\, z_{406}$$

$$z_{467} = z_{374} + z_{191}\, z_{409} - z_{178}\, z_{407}$$

$$z_{468} = z_{358} + z_{189}\, z_{466} - z_{176}\, z_{464}$$

$$z_{469} = z_{364} + z_{192}\, z_{466} - z_{179}\, z_{464}$$

$$z_{470} = z_{369} + z_{193}\, z_{466} - z_{180}\, z_{464}$$

$$z_{471} = z_{371} + z_{191}\, z_{466} - z_{178}\, z_{464}$$

$$z_{472} = z_{373} + z_{188}\, z_{466} - z_{175}\, z_{464}$$

$$z_{473} = z_{372} + z_{187}\, z_{466} - z_{174}\, z_{464}$$

$$z_{474} = z_{183}\, z_{464} - z_{196}\, z_{466}$$

$$z_{475} = z_{185}\, z_{464} - z_{198}\, z_{466}$$

$$z_{476} = z_{186}\, z_{464} - z_{199}\, z_{466}$$

$$z_{477} = z_{184}\, z_{464} - z_{197}\, z_{466}$$

$$z_{478} = z_{182}\, z_{464} - z_{195}\, z_{466}$$

$$z_{479} = z_{181}\, z_{464} - z_{194}\, z_{466}$$

$$z_{480} = z_{465} - z_{177}\, z_{464} - z_{190}\, z_{466}$$

$$z_{481} = z_{467} + z_{464}\, z_{268} - z_{466}\, z_{269}$$

$$z_{482} = z_{188}\, z_{406} - z_{175}\, z_{405}$$

$$z_{483} = z_{188}\, z_{403} - z_{175}\, z_{401}$$

$$z_{484} = z_{188}\, z_{408} - z_{175}\, z_{406}$$

$$z_{485} = z_{377} + z_{188}\, z_{409} - z_{175}\, z_{407}$$

$$z_{486} = z_{355} + z_{189}\, z_{484} - z_{176}\, z_{482}$$

$$z_{487} = z_{362} + z_{192}\, z_{484} - z_{179}\, z_{482}$$

$$z_{488} = z_{368} + z_{193}\, z_{484} - z_{180}\, z_{482}$$

$$z_{489} = z_{373} + z_{191}\, z_{484} - z_{178}\, z_{482}$$

$$z_{490} = z_{375} + z_{188}\, z_{484} - z_{175}\, z_{482}$$

$$z_{491} = z_{376} + z_{187}\, z_{484} - z_{174}\, z_{482}$$

$$z_{492} = z_{183}\, z_{482} - z_{196}\, z_{484}$$

$$z_{493} = z_{185}\, z_{482} - z_{198}\, z_{484}$$

$$z_{494} = z_{186}\, z_{482} - z_{199}\, z_{484}$$

$$z_{495} = z_{184}\, z_{482} - z_{197}\, z_{484}$$

$$z_{496} = z_{182}\, z_{482} - z_{195}\, z_{484}$$

$$z_{497} = z_{181}\, z_{482} - z_{194}\, z_{484}$$

$$z_{498} = z_{483} - z_{177}\, z_{482} - z_{190}\, z_{484}$$

$$z_{499} = z_{485} + z_{482}\, z_{268} - z_{484}\, z_{269}$$

$$z_{500} = z_{187}\, z_{406} - z_{174}\, z_{405}$$

$$z_{501} = z_{187}\, z_{403} - z_{174}\, z_{401}$$

$$z_{502} = z_{187}\, z_{408} - z_{174}\, z_{406}$$

$$z_{503} = z_{379} + z_{187}\, z_{409} - z_{174}\, z_{407}$$

$$z_{504} = z_{353} + z_{189}\, z_{502} - z_{176}\, z_{500}$$

$$z_{505} = z_{360} + z_{192}\, z_{502} - z_{179}\, z_{500}$$

$$z_{506} = z_{366} + z_{193}\, z_{502} - z_{180}\, z_{500}$$

$$z_{507} = z_{372} + z_{191}\, z_{502} - z_{178}\, z_{500}$$

$$z_{508} = z_{376} + z_{188}\, z_{502} - z_{175}\, z_{500}$$

$$z_{509} = z_{378} + z_{187}\, z_{502} - z_{174}\, z_{500}$$

$$z_{510} = z_{183}\, z_{500} - z_{196}\, z_{502}$$

$$z_{511} = z_{185}\, z_{500} - z_{198}\, z_{502}$$

$$z_{512} = z_{186}\, z_{500} - z_{199}\, z_{502}$$

$$z_{513} = z_{184}\, z_{500} - z_{197}\, z_{502}$$

$$z_{514} = z_{182}\, z_{500} - z_{195}\, z_{502}$$

$$z_{515} = z_{181}\, z_{500} - z_{194}\, z_{502}$$

$$z_{516} = z_{501} - z_{177}\, z_{500} - z_{190}\, z_{502}$$

$$z_{517} = z_{503} + z_{500}\, z_{268} - z_{502}\, z_{269}$$

$$z_{518} = z_{183}\, z_{405} - z_{196}\, z_{406}$$

$$z_{519} = z_{183}\, z_{401} - z_{196}\, z_{403}$$

$$z_{520} = z_{183}\, z_{406} - z_{196}\, z_{408}$$

$$z_{521} = z_{386} + z_{183}\, z_{407} - z_{196}\, z_{409}$$

$$z_{522} = z_{189}\, z_{520} - z_{176}\, z_{518}$$

$$z_{523} = z_{192}\, z_{520} - z_{179}\, z_{518}$$

$$z_{524} = z_{193}\, z_{520} - z_{180}\, z_{518}$$

$$z_{525} = z_{191}\, z_{520} - z_{178}\, z_{518}$$

$$z_{526} = z_{188}\, z_{520} - z_{175}\, z_{518}$$

$$z_{527} = z_{187}\, z_{520} - z_{174}\, z_{518}$$

$$z_{528} = z_{383} + z_{183}\, z_{518} - z_{196}\, z_{520}$$

$$z_{529} = z_{384} + z_{185}\, z_{518} - z_{198}\, z_{520}$$

$$z_{530} = z_{186}\, z_{518} - z_{381} - z_{199}\, z_{520}$$

$$z_{531} = z_{385} + z_{184}\, z_{518} - z_{197}\, z_{520}$$

$$z_{532} = z_{382} + z_{182}\, z_{518} - z_{195}\, z_{520}$$

$$z_{533} = z_{380} + z_{181}\, z_{518} - z_{194}\, z_{520}$$

$$z_{534} = z_{519} - z_{177}\, z_{518} - z_{190}\, z_{520}$$

$$z_{535} = z_{521} + z_{518}\, z_{268} - z_{520}\, z_{269}$$

$$z_{536} = z_{185}\, z_{405} - z_{198}\, z_{406}$$

$$z_{537} = z_{185}\, z_{401} - z_{198}\, z_{403}$$

$$z_{538} = z_{185}\, z_{406} - z_{198}\, z_{408}$$

$$z_{539} = z_{392} + z_{185}\, z_{407} - z_{198}\, z_{409}$$

$$z_{540} = z_{189}\, z_{538} - z_{176}\, z_{536}$$

$$z_{541} = z_{192}\, z_{538} - z_{179}\, z_{536}$$

$$z_{542} = z_{193}\, z_{538} - z_{180}\, z_{536}$$

$$z_{543} = z_{191}\, z_{538} - z_{178}\, z_{536}$$

$$z_{544} = z_{188}\, z_{538} - z_{175}\, z_{536}$$

$$z_{545} = z_{187}\, z_{538} - z_{174}\, z_{536}$$

$$z_{546} = z_{384} + z_{183}\, z_{536} - z_{196}\, z_{538}$$

$$z_{547} = z_{390} + z_{185}\, z_{536} - z_{198}\, z_{538}$$

$$z_{548} = z_{186}\, z_{536} - z_{388} - z_{199}\, z_{538}$$

$$z_{549} = z_{391} + z_{184}\, z_{536} - z_{197}\, z_{538}$$

$$z_{550} = z_{389} + z_{182}\, z_{536} - z_{195}\, z_{538}$$

$$z_{551} = z_{387} + z_{181}\, z_{536} - z_{194}\, z_{538}$$

$$z_{552} = z_{537} - z_{177}\, z_{536} - z_{190}\, z_{538}$$

$$z_{553} = z_{539} + z_{536}\, z_{268} - z_{538}\, z_{269}$$

$$z_{554} = z_{186}\, z_{405} - z_{199}\, z_{406}$$

$$z_{555} = z_{186}\, z_{401} - z_{199}\, z_{403}$$

$$z_{556} = z_{186}\, z_{406} - z_{199}\, z_{408}$$

$$z_{557} = z_{397} + z_{186}\, z_{407} - z_{199}\, z_{409}$$

$$z_{558} = z_{189}\, z_{556} - z_{176}\, z_{554}$$

$$z_{559} = z_{192}\, z_{556} - z_{179}\, z_{554}$$

$$z_{560} = z_{193}\, z_{556} - z_{180}\, z_{554}$$

$$z_{561} = z_{191}\, z_{556} - z_{178}\, z_{554}$$

$$z_{562} = z_{188}\, z_{556} - z_{175}\, z_{554}$$

$$z_{563} = z_{187}\, z_{556} - z_{174}\, z_{554}$$

$$z_{564} = z_{183}\, z_{554} - z_{381} - z_{196}\, z_{556}$$

$$z_{565} = z_{185}\, z_{554} - z_{388} - z_{198}\, z_{556}$$

$$z_{566} = z_{394} + z_{186}\, z_{554} - z_{199}\, z_{556}$$

$$z_{567} = z_{396} + z_{184}\, z_{554} - z_{197}\, z_{556}$$

$$z_{568} = z_{395} + z_{182}\, z_{554} - z_{195}\, z_{556}$$

$$z_{569} = z_{393} + z_{181}\, z_{554} - z_{194}\, z_{556}$$

$$z_{570} = z_{555} - z_{177}\, z_{554} - z_{190}\, z_{556}$$

$$z_{571} = z_{557} + z_{554}\, z_{268} - z_{556}\, z_{269}$$

$$z_{572} = z_{184}\, z_{405} - z_{197}\, z_{406}$$

$$z_{573} = z_{184}\, z_{401} - z_{197}\, z_{403}$$

$$z_{574} = z_{184}\, z_{406} - z_{197}\, z_{408}$$

$$z_{575} = z_{398} + z_{184}\, z_{407} - z_{197}\, z_{409}$$

$$z_{576} = z_{189}\, z_{574} - z_{176}\, z_{572}$$

$$z_{577} = z_{192}\, z_{574} - z_{179}\, z_{572}$$

$$z_{578} = z_{193}\, z_{574} - z_{180}\, z_{572}$$

$$z_{579} = z_{191}\, z_{574} - z_{178}\, z_{572}$$

$$z_{580} = z_{188}\, z_{574} - z_{175}\, z_{572}$$

$$z_{581} = z_{187}\, z_{574} - z_{174}\, z_{572}$$

$$z_{582} = z_{385} + z_{183}\, z_{572} - z_{196}\, z_{574}$$

$$z_{583} = z_{391} + z_{185}\, z_{572} - z_{198}\, z_{574}$$

$$z_{584} = z_{396} + z_{186}\, z_{572} - z_{199}\, z_{574}$$

$$z_{585} = z_{371} + z_{184}\, z_{572} - z_{197}\, z_{574}$$

$$z_{586} = z_{373} + z_{182}\, z_{572} - z_{195}\, z_{574}$$

$$z_{587} = z_{372} + z_{181}\, z_{572} - z_{194}\, z_{574}$$

$$z_{588} = z_{573} - z_{177}\, z_{572} - z_{190}\, z_{574}$$

$$z_{589} = z_{575} + z_{572}\, z_{268} - z_{574}\, z_{269}$$

$$z_{590} = z_{182}\, z_{405} - z_{195}\, z_{406}$$

$$z_{591} = z_{182}\, z_{401} - z_{195}\, z_{403}$$

$$z_{592} = z_{182}\, z_{406} - z_{195}\, z_{408}$$

$$z_{593} = z_{399} + z_{182}\, z_{407} - z_{195}\, z_{409}$$

$$z_{594} = z_{189}\, z_{592} - z_{176}\, z_{590}$$

$$z_{595} = z_{192}\, z_{592} - z_{179}\, z_{590}$$

$$z_{596} = z_{193}\, z_{592} - z_{180}\, z_{590}$$

$$z_{597} = z_{191}\, z_{592} - z_{178}\, z_{590}$$

$$z_{598} = z_{188}\, z_{592} - z_{175}\, z_{590}$$

$$z_{599} = z_{187}\, z_{592} - z_{174}\, z_{590}$$

$$z_{600} = z_{382} + z_{183}\, z_{590} - z_{196}\, z_{592}$$

$$z_{601} = z_{389} + z_{185}\, z_{590} - z_{198}\, z_{592}$$

$$z_{602} = z_{395} + z_{186}\, z_{590} - z_{199}\, z_{592}$$

$$z_{603} = z_{373} + z_{184}\, z_{590} - z_{197}\, z_{592}$$

$$z_{604} = z_{375} + z_{182}\, z_{590} - z_{195}\, z_{592}$$

$$z_{605} = z_{376} + z_{181}\, z_{590} - z_{194}\, z_{592}$$

$$z_{606} = z_{591} - z_{177}\, z_{590} - z_{190}\, z_{592}$$

$$z_{607} = z_{593} + z_{590}\, z_{268} - z_{592}\, z_{269}$$

$$z_{608} = z_{181}\, z_{405} - z_{194}\, z_{406}$$

$$z_{609} = z_{181}\, z_{401} - z_{194}\, z_{403}$$

$$z_{610} = z_{181}\, z_{406} - z_{194}\, z_{408}$$

$$z_{611} = z_{400} + z_{181}\, z_{407} - z_{194}\, z_{409}$$

$$z_{612} = z_{189}\, z_{610} - z_{176}\, z_{608}$$

$$z_{613} = z_{192}\, z_{610} - z_{179}\, z_{608}$$

$$z_{614} = z_{193}\, z_{610} - z_{180}\, z_{608}$$

$$z_{615} = z_{191}\, z_{610} - z_{178}\, z_{608}$$

$$z_{616} = z_{188}\, z_{610} - z_{175}\, z_{608}$$

$$z_{617} = z_{187}\, z_{610} - z_{174}\, z_{608}$$

$$z_{618} = z_{380} + z_{183}\, z_{608} - z_{196}\, z_{610}$$

$$z_{619} = z_{387} + z_{185}\, z_{608} - z_{198}\, z_{610}$$

$$z_{620} = z_{393} + z_{186}\, z_{608} - z_{199}\, z_{610}$$

$$z_{621} = z_{372} + z_{184}\, z_{608} - z_{197}\, z_{610}$$

$$z_{622} = z_{376} + z_{182}\, z_{608} - z_{195}\, z_{610}$$

$$z_{623} = z_{378} + z_{181}\, z_{608} - z_{194}\, z_{610}$$

$$z_{624} = z_{609} - z_{177}\, z_{608} - z_{190}\, z_{610}$$

$$z_{625} = z_{611} + z_{608}\, z_{268} - z_{610}\, z_{269}$$

$$z_{626} = z_{401} - z_{177}\, z_{405} - z_{190}\, z_{406}$$

$$z_{627} = z_{402} - z_{177}\, z_{401} - z_{190}\, z_{403}$$

$$z_{628} = z_{403} - z_{177}\, z_{406} - z_{190}\, z_{408}$$

$$z_{629} = z_{404} - z_{177}\, z_{407} - z_{190}\, z_{409}$$

$$z_{630} = z_{189}\, z_{628} - z_{176}\, z_{626}$$

$$z_{631} = z_{192}\, z_{628} - z_{179}\, z_{626}$$

$$z_{632} = z_{193}\, z_{628} - z_{180}\, z_{626}$$

$$z_{633} = z_{191}\, z_{628} - z_{178}\, z_{626}$$

$$z_{634} = z_{188}\, z_{628} - z_{175}\, z_{626}$$

$$z_{635} = z_{187}\, z_{628} - z_{174}\, z_{626}$$

$$z_{636} = z_{183}\, z_{626} - z_{196}\, z_{628}$$

$$z_{637} = z_{185}\, z_{626} - z_{198}\, z_{628}$$

$$z_{638} = z_{186}\, z_{626} - z_{199}\, z_{628}$$

$$z_{639} = z_{184}\, z_{626} - z_{197}\, z_{628}$$

$$z_{640} = z_{182}\, z_{626} - z_{195}\, z_{628}$$

$$z_{641} = z_{181}\, z_{626} - z_{194}\, z_{628}$$

$$z_{642} = z_{627} - z_{177}\, z_{626} - z_{190}\, z_{628}$$

$$z_{643} = z_{629} + z_{626}\, z_{268} - z_{628}\, z_{269}$$

$$z_{644} = z_{309} - z_{427}$$

$$z_{645} = z_{310} - z_{445}$$

$$z_{646} = z_{311} - z_{463}$$

$$z_{647} = z_{314} - z_{481}$$

$$z_{648} = z_{316} - z_{499}$$

$$z_{649} = z_{317} - z_{517}$$

$$z_{650} = z_{318} - z_{535}$$

$$z_{651} = z_{319} - z_{553}$$

$$z_{652} = z_{320} - z_{571}$$

$$z_{653} = z_{321} - z_{589}$$

$$z_{654} = z_{322} - z_{607}$$

$$z_{655} = z_{323} - z_{625}$$

$$z_{656} = -z_{324} - z_{643}$$

# 5 Dynamic Equations of the Multi-Lift Model

The following equations describe the dynamics of the multi-lift model, presented in the thesis main document [Ber13, pages 76ff.], for three coupled helicopters (multi-lift configuration). The variables $z_{xyz}$ represent intermediate results, which are generated automatically.

$$
\begin{aligned}
0 = {} & z_{897} - z_{504}\,\dot{u}_{h1} - z_{505}\,\dot{v}_{h1} - z_{506}\,\dot{w}_{h1} - z_{507}\,\dot{p}_{h1} - z_{508}\,\dot{q}_{h1} - z_{509}\,\dot{r}_{h1} \\
& - z_{510}\,\dot{u}_{h2} - z_{511}\,\dot{v}_{h2} - z_{512}\,\dot{w}_{h2} - z_{513}\,\dot{p}_{h2} - z_{514}\,\dot{q}_{h2} - z_{515}\,\dot{r}_{h2} \\
& - z_{516}\,\dot{u}_{h3} - z_{517}\,\dot{v}_{h3} - z_{518}\,\dot{w}_{h3} - z_{519}\,\dot{p}_{h3} - z_{520}\,\dot{q}_{h3} - z_{521}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = {} & z_{898} - z_{526}\,\dot{u}_{h1} - z_{527}\,\dot{v}_{h1} - z_{528}\,\dot{w}_{h1} - z_{529}\,\dot{p}_{h1} - z_{530}\,\dot{q}_{h1} - z_{531}\,\dot{r}_{h1} \\
& - z_{532}\,\dot{u}_{h2} - z_{533}\,\dot{v}_{h2} - z_{534}\,\dot{w}_{h2} - z_{535}\,\dot{p}_{h2} - z_{536}\,\dot{q}_{h2} - z_{537}\,\dot{r}_{h2} \\
& - z_{538}\,\dot{u}_{h3} - z_{539}\,\dot{v}_{h3} - z_{540}\,\dot{w}_{h3} - z_{541}\,\dot{p}_{h3} - z_{542}\,\dot{q}_{h3} - z_{543}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = {} & z_{899} - z_{548}\,\dot{u}_{h1} - z_{549}\,\dot{v}_{h1} - z_{550}\,\dot{w}_{h1} - z_{551}\,\dot{p}_{h1} - z_{552}\,\dot{q}_{h1} - z_{553}\,\dot{r}_{h1} \\
& - z_{554}\,\dot{u}_{h2} - z_{555}\,\dot{v}_{h2} - z_{556}\,\dot{w}_{h2} - z_{557}\,\dot{p}_{h2} - z_{558}\,\dot{q}_{h2} - z_{559}\,\dot{r}_{h2} \\
& - z_{560}\,\dot{u}_{h3} - z_{561}\,\dot{v}_{h3} - z_{562}\,\dot{w}_{h3} - z_{563}\,\dot{p}_{h3} - z_{564}\,\dot{q}_{h3} - z_{565}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = {} & z_{900} - z_{570}\,\dot{u}_{h1} - z_{571}\,\dot{v}_{h1} - z_{572}\,\dot{w}_{h1} - z_{573}\,\dot{p}_{h1} - z_{574}\,\dot{q}_{h1} - z_{575}\,\dot{r}_{h1} \\
& - z_{576}\,\dot{u}_{h2} - z_{577}\,\dot{v}_{h2} - z_{578}\,\dot{w}_{h2} - z_{579}\,\dot{p}_{h2} - z_{580}\,\dot{q}_{h2} - z_{581}\,\dot{r}_{h2} \\
& - z_{582}\,\dot{u}_{h3} - z_{583}\,\dot{v}_{h3} - z_{584}\,\dot{w}_{h3} - z_{585}\,\dot{p}_{h3} - z_{586}\,\dot{q}_{h3} - z_{587}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = {} & z_{901} - z_{592}\,\dot{u}_{h1} - z_{593}\,\dot{v}_{h1} - z_{594}\,\dot{w}_{h1} - z_{595}\,\dot{p}_{h1} - z_{596}\,\dot{q}_{h1} - z_{597}\,\dot{r}_{h1} \\
& - z_{598}\,\dot{u}_{h2} - z_{599}\,\dot{v}_{h2} - z_{600}\,\dot{w}_{h2} - z_{601}\,\dot{p}_{h2} - z_{602}\,\dot{q}_{h2} - z_{603}\,\dot{r}_{h2} \\
& - z_{604}\,\dot{u}_{h3} - z_{605}\,\dot{v}_{h3} - z_{606}\,\dot{w}_{h3} - z_{607}\,\dot{p}_{h3} - z_{608}\,\dot{q}_{h3} - z_{609}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = {} & z_{902} - z_{614}\,\dot{u}_{h1} - z_{615}\,\dot{v}_{h1} - z_{616}\,\dot{w}_{h1} - z_{617}\,\dot{p}_{h1} - z_{618}\,\dot{q}_{h1} - z_{619}\,\dot{r}_{h1} \\
& - z_{620}\,\dot{u}_{h2} - z_{621}\,\dot{v}_{h2} - z_{622}\,\dot{w}_{h2} - z_{623}\,\dot{p}_{h2} - z_{624}\,\dot{q}_{h2} - z_{625}\,\dot{r}_{h2} \\
& - z_{626}\,\dot{u}_{h3} - z_{627}\,\dot{v}_{h3} - z_{628}\,\dot{w}_{h3} - z_{629}\,\dot{p}_{h3} - z_{630}\,\dot{q}_{h3} - z_{631}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = {} & z_{903} - z_{636}\,\dot{u}_{h1} - z_{637}\,\dot{v}_{h1} - z_{638}\,\dot{w}_{h1} - z_{639}\,\dot{p}_{h1} - z_{640}\,\dot{q}_{h1} - z_{641}\,\dot{r}_{h1} \\
& - z_{642}\,\dot{u}_{h2} - z_{643}\,\dot{v}_{h2} - z_{644}\,\dot{w}_{h2} - z_{645}\,\dot{p}_{h2} - z_{646}\,\dot{q}_{h2} - z_{647}\,\dot{r}_{h2} \\
& - z_{648}\,\dot{u}_{h3} - z_{649}\,\dot{v}_{h3} - z_{650}\,\dot{w}_{h3} - z_{651}\,\dot{p}_{h3} - z_{652}\,\dot{q}_{h3} - z_{653}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = {} & z_{904} - z_{658}\,\dot{u}_{h1} - z_{659}\,\dot{v}_{h1} - z_{660}\,\dot{w}_{h1} - z_{661}\,\dot{p}_{h1} - z_{662}\,\dot{q}_{h1} - z_{663}\,\dot{r}_{h1} \\
& - z_{664}\,\dot{u}_{h2} - z_{665}\,\dot{v}_{h2} - z_{666}\,\dot{w}_{h2} - z_{667}\,\dot{p}_{h2} - z_{668}\,\dot{q}_{h2} - z_{669}\,\dot{r}_{h2} \\
& - z_{670}\,\dot{u}_{h3} - z_{671}\,\dot{v}_{h3} - z_{672}\,\dot{w}_{h3} - z_{673}\,\dot{p}_{h3} - z_{674}\,\dot{q}_{h3} - z_{675}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = {} & z_{905} - z_{680}\,\dot{u}_{h1} - z_{681}\,\dot{v}_{h1} - z_{682}\,\dot{w}_{h1} - z_{683}\,\dot{p}_{h1} - z_{684}\,\dot{q}_{h1} - z_{685}\,\dot{r}_{h1} \\
& - z_{686}\,\dot{u}_{h2} - z_{687}\,\dot{v}_{h2} - z_{688}\,\dot{w}_{h2} - z_{689}\,\dot{p}_{h2} - z_{690}\,\dot{q}_{h2} - z_{691}\,\dot{r}_{h2} \\
& - z_{692}\,\dot{u}_{h3} - z_{693}\,\dot{v}_{h3} - z_{694}\,\dot{w}_{h3} - z_{695}\,\dot{p}_{h3} - z_{696}\,\dot{q}_{h3} - z_{697}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = z_{906} &- z_{702}\,\dot{u}_{h1} - z_{703}\,\dot{v}_{h1} - z_{704}\,\dot{w}_{h1} - z_{705}\,\dot{p}_{h1} - z_{706}\,\dot{q}_{h1} - z_{707}\,\dot{r}_{h1} \\
&- z_{708}\,\dot{u}_{h2} - z_{709}\,\dot{v}_{h2} - z_{710}\,\dot{w}_{h2} - z_{711}\,\dot{p}_{h2} - z_{712}\,\dot{q}_{h2} - z_{713}\,\dot{r}_{h2} \\
&- z_{714}\,\dot{u}_{h3} - z_{715}\,\dot{v}_{h3} - z_{716}\,\dot{w}_{h3} - z_{717}\,\dot{p}_{h3} - z_{718}\,\dot{q}_{h3} - z_{719}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = z_{907} &- z_{724}\,\dot{u}_{h1} - z_{725}\,\dot{v}_{h1} - z_{726}\,\dot{w}_{h1} - z_{727}\,\dot{p}_{h1} - z_{728}\,\dot{q}_{h1} - z_{729}\,\dot{r}_{h1} \\
&- z_{730}\,\dot{u}_{h2} - z_{731}\,\dot{v}_{h2} - z_{732}\,\dot{w}_{h2} - z_{733}\,\dot{p}_{h2} - z_{734}\,\dot{q}_{h2} - z_{735}\,\dot{r}_{h2} \\
&- z_{736}\,\dot{u}_{h3} - z_{737}\,\dot{v}_{h3} - z_{738}\,\dot{w}_{h3} - z_{739}\,\dot{p}_{h3} - z_{740}\,\dot{q}_{h3} - z_{741}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = z_{908} &- z_{746}\,\dot{u}_{h1} - z_{747}\,\dot{v}_{h1} - z_{748}\,\dot{w}_{h1} - z_{749}\,\dot{p}_{h1} - z_{750}\,\dot{q}_{h1} - z_{751}\,\dot{r}_{h1} \\
&- z_{752}\,\dot{u}_{h2} - z_{753}\,\dot{v}_{h2} - z_{754}\,\dot{w}_{h2} - z_{755}\,\dot{p}_{h2} - z_{756}\,\dot{q}_{h2} - z_{757}\,\dot{r}_{h2} \\
&- z_{758}\,\dot{u}_{h3} - z_{759}\,\dot{v}_{h3} - z_{760}\,\dot{w}_{h3} - z_{761}\,\dot{p}_{h3} - z_{762}\,\dot{q}_{h3} - z_{763}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = z_{909} &- z_{768}\,\dot{u}_{h1} - z_{769}\,\dot{v}_{h1} - z_{770}\,\dot{w}_{h1} - z_{771}\,\dot{p}_{h1} - z_{772}\,\dot{q}_{h1} - z_{773}\,\dot{r}_{h1} \\
&- z_{774}\,\dot{u}_{h2} - z_{775}\,\dot{v}_{h2} - z_{776}\,\dot{w}_{h2} - z_{777}\,\dot{p}_{h2} - z_{778}\,\dot{q}_{h2} - z_{779}\,\dot{r}_{h2} \\
&- z_{780}\,\dot{u}_{h3} - z_{781}\,\dot{v}_{h3} - z_{782}\,\dot{w}_{h3} - z_{783}\,\dot{p}_{h3} - z_{784}\,\dot{q}_{h3} - z_{785}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = z_{910} &- z_{790}\,\dot{u}_{h1} - z_{791}\,\dot{v}_{h1} - z_{792}\,\dot{w}_{h1} - z_{793}\,\dot{p}_{h1} - z_{794}\,\dot{q}_{h1} - z_{795}\,\dot{r}_{h1} \\
&- z_{796}\,\dot{u}_{h2} - z_{797}\,\dot{v}_{h2} - z_{798}\,\dot{w}_{h2} - z_{799}\,\dot{p}_{h2} - z_{800}\,\dot{q}_{h2} - z_{801}\,\dot{r}_{h2} \\
&- z_{802}\,\dot{u}_{h3} - z_{803}\,\dot{v}_{h3} - z_{804}\,\dot{w}_{h3} - z_{805}\,\dot{p}_{h3} - z_{806}\,\dot{q}_{h3} - z_{807}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = z_{911} &- z_{812}\,\dot{u}_{h1} - z_{813}\,\dot{v}_{h1} - z_{814}\,\dot{w}_{h1} - z_{815}\,\dot{p}_{h1} - z_{816}\,\dot{q}_{h1} - z_{817}\,\dot{r}_{h1} \\
&- z_{818}\,\dot{u}_{h2} - z_{819}\,\dot{v}_{h2} - z_{820}\,\dot{w}_{h2} - z_{821}\,\dot{p}_{h2} - z_{822}\,\dot{q}_{h2} - z_{823}\,\dot{r}_{h2} \\
&- z_{824}\,\dot{u}_{h3} - z_{825}\,\dot{v}_{h3} - z_{826}\,\dot{w}_{h3} - z_{827}\,\dot{p}_{h3} - z_{828}\,\dot{q}_{h3} - z_{829}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = z_{912} &- z_{834}\,\dot{u}_{h1} - z_{835}\,\dot{v}_{h1} - z_{836}\,\dot{w}_{h1} - z_{837}\,\dot{p}_{h1} - z_{838}\,\dot{q}_{h1} - z_{839}\,\dot{r}_{h1} \\
&- z_{840}\,\dot{u}_{h2} - z_{841}\,\dot{v}_{h2} - z_{842}\,\dot{w}_{h2} - z_{843}\,\dot{p}_{h2} - z_{844}\,\dot{q}_{h2} - z_{845}\,\dot{r}_{h2} \\
&- z_{846}\,\dot{u}_{h3} - z_{847}\,\dot{v}_{h3} - z_{848}\,\dot{w}_{h3} - z_{849}\,\dot{p}_{h3} - z_{850}\,\dot{q}_{h3} - z_{851}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = z_{913} &- z_{856}\,\dot{u}_{h1} - z_{857}\,\dot{v}_{h1} - z_{858}\,\dot{w}_{h1} - z_{859}\,\dot{p}_{h1} - z_{860}\,\dot{q}_{h1} - z_{861}\,\dot{r}_{h1} \\
&- z_{862}\,\dot{u}_{h2} - z_{863}\,\dot{v}_{h2} - z_{864}\,\dot{w}_{h2} - z_{865}\,\dot{p}_{h2} - z_{866}\,\dot{q}_{h2} - z_{867}\,\dot{r}_{h2} \\
&- z_{868}\,\dot{u}_{h3} - z_{869}\,\dot{v}_{h3} - z_{870}\,\dot{w}_{h3} - z_{871}\,\dot{p}_{h3} - z_{872}\,\dot{q}_{h3} - z_{873}\,\dot{r}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
0 = z_{914} &- z_{878}\,\dot{u}_{h1} - z_{879}\,\dot{v}_{h1} - z_{880}\,\dot{w}_{h1} - z_{881}\,\dot{p}_{h1} - z_{882}\,\dot{q}_{h1} - z_{883}\,\dot{r}_{h1} \\
&- z_{884}\,\dot{u}_{h2} - z_{885}\,\dot{v}_{h2} - z_{886}\,\dot{w}_{h2} - z_{887}\,\dot{p}_{h2} - z_{888}\,\dot{q}_{h2} - z_{889}\,\dot{r}_{h2} \\
&- z_{890}\,\dot{u}_{h3} - z_{891}\,\dot{v}_{h3} - z_{892}\,\dot{w}_{h3} - z_{893}\,\dot{p}_{h3} - z_{894}\,\dot{q}_{h3} - z_{895}\,\dot{r}_{h3}
\end{aligned}
$$

The equations need to be solved for the desired variables ($\dot{u}_{hx}$, $\dot{v}_{hx}$, $\dot{w}_{hx}$, $\dot{p}_{hx}$, $\dot{q}_{hx}$, $\dot{r}_{hx}$), with $x \in \{1, 2, 3\}$, to get the explicit equations.

The following equations define the $z_{xyz}$ variables:

$$
\begin{aligned}
z_6 &= \sin(\varphi_{h1}) \\
z_{52} &= \tan(\theta_{h1}) \\
z_{53} &= z_6\, z_{52} \\
z_8 &= \cos(\varphi_{h1}) \\
z_{54} &= z_8\, z_{52}
\end{aligned}
$$

$$\dot{\varphi}_{h1} = p_{h1} + z_{53}\, q_{h1} + z_{54}\, r_{h1}$$
$$\dot{\theta}_{h1} = z_8\, q_{h1} - z_6\, r_{h1}$$
$$z_{49} = \cos(\theta_{h1})$$
$$z_{50} = z_6 \,/ z_{49}$$
$$z_{51} = z_8 \,/ z_{49}$$
$$\dot{\psi}_{h1} = z_{50}\, q_{h1} + z_{51}\, r_{h1}$$
$$z_{22} = \sin(\varphi_{h2})$$
$$z_{58} = \tan(\theta_{h2})$$
$$z_{59} = z_{22}\, z_{58}$$
$$z_{24} = \cos(\varphi_{h2})$$
$$z_{60} = z_{24}\, z_{58}$$
$$\dot{\varphi}_{h2} = p_{h2} + z_{59}\, q_{h2} + z_{60}\, r_{h2}$$
$$\dot{\theta}_{h2} = z_{24}\, q_{h2} - z_{22}\, r_{h2}$$
$$z_{55} = \cos(\theta_{h2})$$
$$z_{56} = z_{22} \,/ z_{55}$$
$$z_{57} = z_{24} \,/ z_{55}$$
$$\dot{\psi}_{h2} = z_{56}\, q_{h2} + z_{57}\, r_{h2}$$
$$z_{38} = \sin(\varphi_{h3})$$
$$z_{64} = \tan(\theta_{h3})$$
$$z_{65} = z_{38}\, z_{64}$$
$$z_{40} = \cos(\varphi_{h3})$$
$$z_{66} = z_{40}\, z_{64}$$
$$\dot{\varphi}_{h3} = p_{h3} + z_{65}\, q_{h3} + z_{66}\, r_{h3}$$
$$\dot{\theta}_{h3} = z_{40}\, q_{h3} - z_{38}\, r_{h3}$$
$$z_{61} = \cos(\theta_{h3})$$
$$z_{62} = z_{38} \,/ z_{61}$$
$$z_{63} = z_{40} \,/ z_{61}$$
$$\dot{\psi}_{h3} = z_{62}\, q_{h3} + z_{63}\, r_{h3}$$
$$z_{147} = z_{h2} - z_l$$

$$
\begin{aligned}
z_{76} &= m_F + m_{MR} \\
z_{78} &= (dOFo_2 m_F + dOMRo_2 m_{MR})/z_{76} \\
z_{90} &= dORo_2 - z_{78} \\
z_{18} &= \pi + \theta_{h2} \\
z_{20} &= \cos(z_{18}) \\
z_{31} &= z_{20}\, z_{22} \\
z_{79} &= (dOFo_3 m_F + dOMRo_3 m_{MR})/z_{76} \\
z_{91} &= dORo_3 - z_{79} \\
z_{32} &= z_{20}\, z_{24} \\
z_{77} &= (dOFo_1 m_F + dOMRo_1 m_{MR})/z_{76} \\
z_{89} &= dORo_1 - z_{77} \\
z_{23} &= \sin(z_{18}) \\
z_{183} &= 2z_{147} + 2z_{90}\, z_{31} + 2z_{91}\, z_{32} - 2z_{89}\, z_{23} \\
z_{132} &= y_{h1} - y_l \\
z_2 &= \pi + \theta_{h1} \\
z_4 &= \cos(z_2) \\
z_1 &= \pi + \psi_{h1} \\
z_9 &= \sin(z_1) \\
z_{12} &= z_4\, z_9 \\
z_3 &= \cos(z_1) \\
z_7 &= \sin(z_2) \\
z_{13} &= z_3\, z_8 + z_6\, z_7\, z_9 \\
z_{14} &= z_7\, z_8\, z_9 - z_3\, z_6 \\
z_{176} &= -2z_{132} - 2z_{89}\, z_{12} - 2z_{90}\, z_{13} - 2z_{91}\, z_{14} \\
z_{34} &= \pi + \theta_{h3} \\
z_{39} &= \sin(z_{34}) \\
z_{161} &= z_{h3} - z_l \\
z_{36} &= \cos(z_{34}) \\
z_{47} &= z_{36}\, z_{38} \\
z_{48} &= z_{36}\, z_{40} \\
z_{196} &= 2z_{89}\, z_{39} - 2z_{161} - 2z_{90}\, z_{47} - 2z_{91}\, z_{48}
\end{aligned}
$$

$$
\begin{aligned}
z_{133} &= z_{h1} - z_l \\
z_{15} &= z_4\, z_6 \\
z_{16} &= z_4\, z_8 \\
z_{177} &= 2z_{89}\, z_7 - 2z_{133} - 2z_{90}\, z_{15} - 2z_{91}\, z_{16} \\
z_{160} &= y_{h3} - y_l \\
z_{33} &= \pi + \psi_{h3} \\
z_{41} &= \sin(z_{33}) \\
z_{44} &= z_{36}\, z_{41} \\
z_{35} &= \cos(z_{33}) \\
z_{45} &= z_{35}\, z_{40} + z_{38}\, z_{39}\, z_{41} \\
z_{46} &= z_{39}\, z_{40}\, z_{41} - z_{35}\, z_{38} \\
z_{194} &= -2z_{160} - 2z_{89}\, z_{44} - 2z_{90}\, z_{45} - 2z_{91}\, z_{46} \\
z_{207} &= z_{176}\, z_{196} - z_{177}\, z_{194} \\
z_{159} &= x_{h3} - x_l \\
z_{37} &= z_{35}\, z_{36} \\
z_{42} &= z_{35}\, z_{38}\, z_{39} - z_{40}\, z_{41} \\
z_{43} &= z_{38}\, z_{41} + z_{35}\, z_{39}\, z_{40} \\
z_{192} &= -2z_{159} - 2z_{89}\, z_{37} - 2z_{90}\, z_{42} - 2z_{91}\, z_{43} \\
z_{182} &= 2z_{89}\, z_{23} - 2z_{147} - 2z_{90}\, z_{31} - 2z_{91}\, z_{32} \\
z_{146} &= y_{h2} - y_l \\
z_{17} &= \pi + \psi_{h2} \\
z_{25} &= \sin(z_{17}) \\
z_{28} &= z_{20}\, z_{25} \\
z_{19} &= \cos(z_{17}) \\
z_{29} &= z_{19}\, z_{24} + z_{22}\, z_{23}\, z_{25} \\
z_{30} &= z_{23}\, z_{24}\, z_{25} - z_{19}\, z_{22} \\
z_{189} &= -2z_{146} - 2z_{89}\, z_{28} - 2z_{90}\, z_{29} - 2z_{91}\, z_{30} \\
z_{202} &= z_{176}\, z_{182} - z_{177}\, z_{189} \\
z_{131} &= x_{h1} - x_l \\
z_5 &= z_3\, z_4 \\
z_{10} &= z_3\, z_6\, z_7 - z_8\, z_9 \\
z_{11} &= z_6\, z_9 + z_3\, z_7\, z_8
\end{aligned}
$$

$$z_{174} = -2z_{131} - 2z_{89}\,z_5 - 2z_{90}\,z_{10} - 2z_{91}\,z_{11}$$

$$z_{145} = x_{h2} - x_l$$

$$z_{21} = z_{19}\,z_{20}$$

$$z_{26} = z_{19}\,z_{22}\,z_{23} - z_{24}\,z_{25}$$

$$z_{27} = z_{22}\,z_{25} + z_{19}\,z_{23}\,z_{24}$$

$$z_{187} = -2z_{145} - 2z_{89}\,z_{21} - 2z_{90}\,z_{26} - 2z_{91}\,z_{27}$$

$$z_{200} = z_{174}\,z_{189} - z_{176}\,z_{187}$$

$$z_{201} = z_{174}\,z_{182} - z_{177}\,z_{187}$$

$$z_{203} = z_{192}\,z_{202} + z_{196}\,z_{200} - z_{194}\,z_{201}$$

$$z_{216} = z_{183}\,z_{207}\,/z_{203}$$

$$z_{154} = z_{23}\,z_{25}$$

$$z_{157} = z_{22}\,z_{23}$$

$$z_{148} = z_{19}\,z_{23}$$

$$z_{158} = z_{23}\,z_{24}$$

$$z_{149} = z_{19}\,z_{20}\,z_{22}$$

$$z_{150} = -z_{19}\,z_{24} - z_{22}\,z_{23}\,z_{25}$$

$$z_{155} = z_{20}\,z_{22}\,z_{25}$$

$$z_{153} = z_{19}\,z_{20}\,z_{24}$$

$$z_{152} = z_{19}\,z_{22} - z_{23}\,z_{24}\,z_{25}$$

$$z_{151} = z_{24}\,z_{25} - z_{19}\,z_{22}\,z_{23}$$

$$z_{156} = z_{20}\,z_{24}\,z_{25}$$

$$\begin{aligned} z_{184} = {} & 2z_{89}\,z_{20}\,z_{22}\,z_{147} + 2z_{89}\,z_{146}\,(z_{21}\,z_{57} + z_{22}\,z_{154}) + 2z_{90}\,z_{147}\,(z_{22}\,z_{157} + z_{32}\,z_{60}) \\ & + 2z_{89}\,z_{145}\,(z_{22}\,z_{148} - z_{28}\,z_{57}) + 2z_{91}\,z_{147}\,(z_{22}\,z_{158} - z_{31}\,z_{60}) \\ & - 2z_{90}\,z_{145}\,(z_{22}\,z_{149} - z_{27}\,z_{60} - z_{57}\,z_{150}) - 2z_{90}\,z_{146}\,(z_{22}\,z_{155} - z_{26}\,z_{57} - z_{30}\,z_{60}) \\ & - 2z_{91}\,z_{145}\,(z_{22}\,z_{153} - z_{57}\,z_{152} - z_{60}\,z_{151}) - 2z_{91}\,z_{146}\,(z_{22}\,z_{156} - z_{27}\,z_{57} - z_{60}\,z_{150}) \end{aligned}$$

$$z_{217} = z_{184}\,z_{207}\,/z_{203}$$

$$\begin{aligned} z_{185} = {} & 2z_{89}\,z_{146}\,(z_{21}\,z_{56} - z_{24}\,z_{154}) + 2z_{90}\,z_{145}\,(z_{24}\,z_{149} + z_{27}\,z_{59} + z_{56}\,z_{150}) \\ & + 2z_{90}\,z_{146}\,(z_{24}\,z_{155} + z_{26}\,z_{56} + z_{30}\,z_{59}) + 2z_{91}\,z_{145}\,(z_{24}\,z_{153} + z_{56}\,z_{152} + z_{59}\,z_{151}) \\ & + 2z_{91}\,z_{146}\,(z_{24}\,z_{156} + z_{27}\,z_{56} + z_{59}\,z_{150}) \\ & - 2z_{89}\,z_{20}\,z_{24}\,z_{147} - 2z_{89}\,z_{145}\,(z_{24}\,z_{148} + z_{28}\,z_{56}) \\ & - 2z_{91}\,z_{147}\,(z_{24}\,z_{158} + z_{31}\,z_{59}) - 2z_{90}\,z_{147}\,(z_{24}\,z_{157} - z_{32}\,z_{59}) \end{aligned}$$

$$z_{218} = z_{185}\,z_{207}\,/z_{203}$$

$$\begin{aligned} z_{186} = {} & 2z_{90}\,z_{27}\,z_{145} + 2z_{90}\,z_{30}\,z_{146} + 2z_{90}\,z_{32}\,z_{147} \\ & + 2z_{91}\,z_{145}\,z_{151} + 2z_{91}\,z_{146}\,z_{150} - 2z_{91}\,z_{31}\,z_{147} \end{aligned}$$

$$z_{219} = z_{186}\,z_{207}\,/z_{203}$$

$$z_{188} = 2z_{145} + 2z_{89}\,z_{21} + 2z_{90}\,z_{26} + 2z_{91}\,z_{27}$$

$$z_{220} = z_{188}\,z_{207}\,/z_{203}$$

$$z_{190} = 2z_{146} + 2z_{89}\,z_{28} + 2z_{90}\,z_{29} + 2z_{91}\,z_{30}$$

$$z_{221} = z_{190}\,z_{207}\,/z_{203}$$

$$z_{173} = 2z_{131} + 2z_{89}\,z_{5} + 2z_{90}\,z_{10} + 2z_{91}\,z_{11}$$

$$z_{204} = z_{189}\,z_{196} - z_{182}\,z_{194}$$

$$z_{210} = z_{173}\,z_{204}\,/z_{203}$$

$$z_{175} = 2z_{132} + 2z_{89}\,z_{12} + 2z_{90}\,z_{13} + 2z_{91}\,z_{14}$$

$$z_{211} = z_{175}\,z_{204}\,/z_{203}$$

$$z_{178} = 2z_{133} + 2z_{90}\,z_{15} + 2z_{91}\,z_{16} - 2z_{89}\,z_{7}$$

$$z_{212} = z_{178}\,z_{204}\,/z_{203}$$

$$z_{140} = z_{7}\,z_{9}$$

$$z_{143} = z_{6}\,z_{7}$$

$$z_{134} = z_{3}\,z_{7}$$

$$z_{144} = z_{7}\,z_{8}$$

$$z_{135} = z_{3}\,z_{4}\,z_{6}$$

$$z_{136} = -z_{3}\,z_{8} - z_{6}\,z_{7}\,z_{9}$$

$$z_{141} = z_{4}\,z_{6}\,z_{9}$$

$$z_{139} = z_{3}\,z_{4}\,z_{8}$$

$$z_{138} = z_{3}\,z_{6} - z_{7}\,z_{8}\,z_{9}$$

$$z_{137} = z_{8}\,z_{9} - z_{3}\,z_{6}\,z_{7}$$

$$z_{142} = z_{4}\,z_{8}\,z_{9}$$

$$\begin{aligned} z_{179} = {} & 2z_{89}\,z_{4}\,z_{6}\,z_{133} + 2z_{89}\,z_{132}\,(z_{5}\,z_{51} + z_{6}\,z_{140}) + 2z_{90}\,z_{133}\,(z_{6}\,z_{143} + z_{16}\,z_{54}) \\ & + 2z_{89}\,z_{131}\,(z_{6}\,z_{134} - z_{12}\,z_{51}) + 2z_{91}\,z_{133}\,(z_{6}\,z_{144} - z_{15}\,z_{54}) \\ & - 2z_{90}\,z_{131}\,(z_{6}\,z_{135} - z_{11}\,z_{54} - z_{51}\,z_{136}) - 2z_{90}\,z_{132}\,(z_{6}\,z_{141} - z_{10}\,z_{51} - z_{14}\,z_{54}) \\ & - 2z_{91}\,z_{131}\,(z_{6}\,z_{139} - z_{51}\,z_{138} - z_{54}\,z_{137}) - 2z_{91}\,z_{132}\,(z_{6}\,z_{142} - z_{11}\,z_{51} - z_{54}\,z_{136}) \end{aligned}$$

$$z_{213} = z_{179}\,z_{204}\,/z_{203}$$

$$\begin{aligned} z_{180} = {} & 2z_{89}\,z_{132}\,(z_{5}\,z_{50} - z_{8}\,z_{140}) + 2z_{90}\,z_{131}\,(z_{8}\,z_{135} + z_{11}\,z_{53} + z_{50}\,z_{136}) \\ & + 2z_{90}\,z_{132}\,(z_{8}\,z_{141} + z_{10}\,z_{50} + z_{14}\,z_{53}) + 2z_{91}\,z_{131}\,(z_{8}\,z_{139} + z_{50}\,z_{138} + z_{53}\,z_{137}) \\ & + 2z_{91}\,z_{132}\,(z_{8}\,z_{142} + z_{11}\,z_{50} + z_{53}\,z_{136}) \\ & - 2z_{89}\,z_{4}\,z_{8}\,z_{133} - 2z_{89}\,z_{131}\,(z_{8}\,z_{134} + z_{12}\,z_{50}) \\ & - 2z_{91}\,z_{133}\,(z_{8}\,z_{144} + z_{15}\,z_{53}) - 2z_{90}\,z_{133}\,(z_{8}\,z_{143} - z_{16}\,z_{53}) \end{aligned}$$

$$z_{214} = z_{180}\,z_{204}\,/z_{203}$$

$$z_{181} = 2z_{90}\,z_{11}\,z_{131} + 2z_{90}\,z_{14}\,z_{132} + 2z_{90}\,z_{16}\,z_{133} + 2z_{91}\,z_{131}\,z_{137} + 2z_{91}\,z_{132}\,z_{136} - 2z_{91}\,z_{15}\,z_{133}$$

$$z_{215} = z_{181}\,z_{204}\,/z_{203}$$

$$z_{191} = 2z_{159} + 2z_{89}\,z_{37} + 2z_{90}\,z_{42} + 2z_{91}\,z_{43}$$

$$z_{222} = z_{191}\,z_{202}\,/z_{203}$$

$$z_{193} = 2z_{160} + 2z_{89}\,z_{44} + 2z_{90}\,z_{45} + 2z_{91}\,z_{46}$$

$$z_{223} = z_{193}\,z_{202}\,/z_{203}$$

$$z_{195} = 2z_{161} + 2z_{90}\,z_{47} + 2z_{91}\,z_{48} - 2z_{89}\,z_{39}$$

$$z_{224} = z_{195}\,z_{202}\,/z_{203}$$

$$z_{168} = z_{39}\,z_{41}$$

$$z_{171} = z_{38}\,z_{39}$$

$$z_{162} = z_{35}\,z_{39}$$

$$z_{172} = z_{39}\,z_{40}$$

$$z_{163} = z_{35}\,z_{36}\,z_{38}$$

$$z_{164} = -z_{35}\,z_{40} - z_{38}\,z_{39}\,z_{41}$$

$$z_{169} = z_{36}\,z_{38}\,z_{41}$$

$$z_{167} = z_{35}\,z_{36}\,z_{40}$$

$$z_{166} = z_{35}\,z_{38} - z_{39}\,z_{40}\,z_{41}$$

$$z_{165} = z_{40}\,z_{41} - z_{35}\,z_{38}\,z_{39}$$

$$z_{170} = z_{36}\,z_{40}\,z_{41}$$

$$\begin{aligned} z_{197} = {} & 2z_{89}\,z_{36}\,z_{38}\,z_{161} + 2z_{89}\,z_{160}\,(z_{37}\,z_{63} + z_{38}\,z_{168}) + 2z_{90}\,z_{161}\,(z_{38}\,z_{171} + z_{48}\,z_{66}) \\ & + 2z_{89}\,z_{159}\,(z_{38}\,z_{162} - z_{44}\,z_{63}) + 2z_{91}\,z_{161}\,(z_{38}\,z_{172} - z_{47}\,z_{66}) \\ & - 2z_{90}\,z_{159}\,(z_{38}\,z_{163} - z_{43}\,z_{66} - z_{63}\,z_{164}) - 2z_{90}\,z_{160}\,(z_{38}\,z_{169} - z_{42}\,z_{63} - z_{46}\,z_{66}) \\ & - 2z_{91}\,z_{159}\,(z_{38}\,z_{167} - z_{63}\,z_{166} - z_{66}\,z_{165}) - 2z_{91}\,z_{160}\,(z_{38}\,z_{170} - z_{43}\,z_{63} - z_{66}\,z_{164}) \end{aligned}$$

$$z_{225} = z_{197}\,z_{202}\,/z_{203}$$

$$\begin{aligned} z_{198} = {} & 2z_{89}\,z_{160}\,(z_{37}\,z_{62} - z_{40}\,z_{168}) + 2z_{90}\,z_{159}\,(z_{40}\,z_{163} + z_{43}\,z_{65} + z_{62}\,z_{164}) \\ & + 2z_{90}\,z_{160}\,(z_{40}\,z_{169} + z_{42}\,z_{62} + z_{46}\,z_{65}) + 2z_{91}\,z_{159}\,(z_{40}\,z_{167} + z_{62}\,z_{166} + z_{65}\,z_{165}) \\ & + 2z_{91}\,z_{160}\,(z_{40}\,z_{170} + z_{43}\,z_{62} + z_{65}\,z_{164}) \\ & - 2z_{89}\,z_{36}\,z_{40}\,z_{161} - 2z_{89}\,z_{159}\,(z_{40}\,z_{162} + z_{44}\,z_{62}) \\ & - 2z_{91}\,z_{161}\,(z_{40}\,z_{172} + z_{47}\,z_{65}) - 2z_{90}\,z_{161}\,(z_{40}\,z_{171} - z_{48}\,z_{65}) \end{aligned}$$

$$z_{226} = z_{198}\,z_{202}\,/z_{203}$$

$$z_{199} = 2z_{90}\,z_{43}\,z_{159} + 2z_{90}\,z_{46}\,z_{160} + 2z_{90}\,z_{48}\,z_{161} + 2z_{91}\,z_{159}\,z_{165} + 2z_{91}\,z_{160}\,z_{164} - 2z_{91}\,z_{47}\,z_{161}$$

$$z_{227} = z_{199}\,z_{202}\,/z_{203}$$

$$
\begin{aligned}
u_l &= z_{216}\, w_{h2} + z_{217}\, r_{h2} + z_{218}\, q_{h2} + z_{219}\, p_{h2} + z_{220}\, u_{h2} + z_{221}\, v_{h2} \\
&\quad - z_{210}\, u_{h1} - z_{211}\, v_{h1} - z_{212}\, w_{h1} - z_{213}\, r_{h1} - z_{214}\, q_{h1} - z_{215}\, p_{h1} \\
&\quad - z_{222}\, u_{h3} - z_{223}\, v_{h3} - z_{224}\, w_{h3} - z_{225}\, r_{h3} - z_{226}\, q_{h3} - z_{227}\, p_{h3}
\end{aligned}
$$

$$z_{205} = z_{187}\, z_{196} - z_{182}\, z_{192}$$

$$z_{228} = z_{173}\, z_{205} \,/ z_{203}$$

$$z_{229} = z_{175}\, z_{205} \,/ z_{203}$$

$$z_{230} = z_{178}\, z_{205} \,/ z_{203}$$

$$z_{231} = z_{179}\, z_{205} \,/ z_{203}$$

$$z_{232} = z_{180}\, z_{205} \,/ z_{203}$$

$$z_{233} = z_{181}\, z_{205} \,/ z_{203}$$

$$z_{240} = z_{191}\, z_{201} \,/ z_{203}$$

$$z_{241} = z_{193}\, z_{201} \,/ z_{203}$$

$$z_{242} = z_{195}\, z_{201} \,/ z_{203}$$

$$z_{243} = z_{197}\, z_{201} \,/ z_{203}$$

$$z_{244} = z_{198}\, z_{201} \,/ z_{203}$$

$$z_{245} = z_{199}\, z_{201} \,/ z_{203}$$

$$z_{208} = z_{174}\, z_{196} - z_{177}\, z_{192}$$

$$z_{234} = z_{183}\, z_{208} \,/ z_{203}$$

$$z_{235} = z_{184}\, z_{208} \,/ z_{203}$$

$$z_{236} = z_{185}\, z_{208} \,/ z_{203}$$

$$z_{237} = z_{186}\, z_{208} \,/ z_{203}$$

$$z_{238} = z_{188}\, z_{208} \,/ z_{203}$$

$$z_{239} = z_{190}\, z_{208} \,/ z_{203}$$

$$
\begin{aligned}
v_l &= z_{228}\, u_{h1} + z_{229}\, v_{h1} + z_{230}\, w_{h1} + z_{231}\, r_{h1} + z_{232}\, q_{h1} + z_{233}\, p_{h1} \\
&\quad + z_{240}\, u_{h3} + z_{241}\, v_{h3} + z_{242}\, w_{h3} + z_{243}\, r_{h3} + z_{244}\, q_{h3} + z_{245}\, p_{h3} \\
&\quad - z_{234}\, w_{h2} - z_{235}\, r_{h2} - z_{236}\, q_{h2} - z_{237}\, p_{h2} - z_{238}\, u_{h2} - z_{239}\, v_{h2}
\end{aligned}
$$

$$z_{209} = z_{174}\, z_{194} - z_{176}\, z_{192}$$

$$z_{252} = z_{183}\, z_{209} \,/ z_{203}$$

$$z_{253} = z_{184}\, z_{209} \,/ z_{203}$$

$$z_{254} = z_{185}\, z_{209} \,/ z_{203}$$

$$
\begin{aligned}
z_{255} &= z_{186}\, z_{209} \,/ z_{203} \\
z_{256} &= z_{188}\, z_{209} \,/ z_{203} \\
z_{257} &= z_{190}\, z_{209} \,/ z_{203} \\
z_{206} &= z_{187}\, z_{194} \; - z_{189}\, z_{192} \\
z_{246} &= z_{173}\, z_{206} \,/ z_{203} \\
z_{247} &= z_{175}\, z_{206} \,/ z_{203} \\
z_{248} &= z_{178}\, z_{206} \,/ z_{203} \\
z_{249} &= z_{179}\, z_{206} \,/ z_{203} \\
z_{250} &= z_{180}\, z_{206} \,/ z_{203} \\
z_{251} &= z_{181}\, z_{206} \,/ z_{203} \\
z_{258} &= z_{191}\, z_{200} \,/ z_{203} \\
z_{259} &= z_{193}\, z_{200} \,/ z_{203} \\
z_{260} &= z_{195}\, z_{200} \,/ z_{203} \\
z_{261} &= z_{197}\, z_{200} \,/ z_{203} \\
z_{262} &= z_{198}\, z_{200} \,/ z_{203} \\
z_{263} &= z_{199}\, z_{200} \,/ z_{203} \\
w_l &= z_{252}\, w_{h2} \; + z_{253}\, r_{h2} \; + z_{254}\, q_{h2} \; + z_{255}\, p_{h2} \; + z_{256}\, u_{h2} \; + z_{257}\, v_{h2} \\
&\quad - z_{246}\, u_{h1} \; - z_{247}\, v_{h1} \; - z_{248}\, w_{h1} \; - z_{249}\, r_{h1} \; - z_{250}\, q_{h1} \; - z_{251}\, p_{h1} \\
&\quad - z_{258}\, u_{h3} \; - z_{259}\, v_{h3} \; - z_{260}\, w_{h3} \; - z_{261}\, r_{h3} \; - z_{262}\, q_{h3} \; - z_{263}\, p_{h3} \\
z_{67} &= \omega_{MR} \; + r_{h1} \\
z_{68} &= q_{h1}\, (r_{h1} \; - z_{67}\,) \\
z_{69} &= p_{h1}\, (r_{h1} \; - z_{67}\,) \\
z_{70} &= \omega_{MR} \; + r_{h2} \\
z_{71} &= q_{h2}\, (r_{h2} \; - z_{70}\,) \\
z_{72} &= p_{h2}\, (r_{h2} \; - z_{70}\,) \\
z_{73} &= \omega_{MR} \; + r_{h3} \\
z_{74} &= q_{h3}\, (r_{h3} \; - z_{73}\,) \\
z_{75} &= p_{h3}\, (r_{h3} \; - z_{73}\,) \\
z_{80} &= dOMRo_1 - z_{77} \\
z_{81} &= dOMRo_2 - z_{78}
\end{aligned}
$$

$$
\begin{aligned}
z_{82} &= dOMRo_3 - z_{79} \\
z_{83} &= dOFo_1 - z_{77} \\
z_{84} &= dOFo_2 - z_{78} \\
z_{85} &= dOFo_3 - z_{79} \\
z_{86} &= dOT_1 - z_{77} \\
z_{88} &= dOT_3 - z_{79} \\
z_{92} &= -q_{h1}\,(z_{80}\,q_{h1} - z_{81}\,p_{h1}) - r_{h1}\,(z_{80}\,r_{h1} - z_{82}\,p_{h1}) \\
z_{93} &= p_{h1}\,(z_{80}\,q_{h1} - z_{81}\,p_{h1}) - r_{h1}\,(z_{81}\,r_{h1} - z_{82}\,q_{h1}) \\
z_{94} &= p_{h1}\,(z_{80}\,r_{h1} - z_{82}\,p_{h1}) + q_{h1}\,(z_{81}\,r_{h1} - z_{82}\,q_{h1}) \\
z_{95} &= -q_{h1}\,(z_{83}\,q_{h1} - z_{84}\,p_{h1}) - r_{h1}\,(z_{83}\,r_{h1} - z_{85}\,p_{h1}) \\
z_{96} &= p_{h1}\,(z_{83}\,q_{h1} - z_{84}\,p_{h1}) - r_{h1}\,(z_{84}\,r_{h1} - z_{85}\,q_{h1}) \\
z_{97} &= p_{h1}\,(z_{83}\,r_{h1} - z_{85}\,p_{h1}) + q_{h1}\,(z_{84}\,r_{h1} - z_{85}\,q_{h1}) \\
z_{104} &= -q_{h2}\,(z_{80}\,q_{h2} - z_{81}\,p_{h2}) - r_{h2}\,(z_{80}\,r_{h2} - z_{82}\,p_{h2}) \\
z_{105} &= p_{h2}\,(z_{80}\,q_{h2} - z_{81}\,p_{h2}) - r_{h2}\,(z_{81}\,r_{h2} - z_{82}\,q_{h2}) \\
z_{106} &= p_{h2}\,(z_{80}\,r_{h2} - z_{82}\,p_{h2}) + q_{h2}\,(z_{81}\,r_{h2} - z_{82}\,q_{h2}) \\
z_{107} &= -q_{h2}\,(z_{83}\,q_{h2} - z_{84}\,p_{h2}) - r_{h2}\,(z_{83}\,r_{h2} - z_{85}\,p_{h2}) \\
z_{108} &= p_{h2}\,(z_{83}\,q_{h2} - z_{84}\,p_{h2}) - r_{h2}\,(z_{84}\,r_{h2} - z_{85}\,q_{h2}) \\
z_{109} &= p_{h2}\,(z_{83}\,r_{h2} - z_{85}\,p_{h2}) + q_{h2}\,(z_{84}\,r_{h2} - z_{85}\,q_{h2}) \\
z_{116} &= -q_{h3}\,(z_{80}\,q_{h3} - z_{81}\,p_{h3}) - r_{h3}\,(z_{80}\,r_{h3} - z_{82}\,p_{h3}) \\
z_{117} &= p_{h3}\,(z_{80}\,q_{h3} - z_{81}\,p_{h3}) - r_{h3}\,(z_{81}\,r_{h3} - z_{82}\,q_{h3}) \\
z_{118} &= p_{h3}\,(z_{80}\,r_{h3} - z_{82}\,p_{h3}) + q_{h3}\,(z_{81}\,r_{h3} - z_{82}\,q_{h3}) \\
z_{119} &= -q_{h3}\,(z_{83}\,q_{h3} - z_{84}\,p_{h3}) - r_{h3}\,(z_{83}\,r_{h3} - z_{85}\,p_{h3}) \\
z_{120} &= p_{h3}\,(z_{83}\,q_{h3} - z_{84}\,p_{h3}) - r_{h3}\,(z_{84}\,r_{h3} - z_{85}\,q_{h3}) \\
z_{121} &= p_{h3}\,(z_{83}\,r_{h3} - z_{85}\,p_{h3}) + q_{h3}\,(z_{84}\,r_{h3} - z_{85}\,q_{h3}) \\
z_{128} &= g\,m_F \\
z_{129} &= g\,m_{MR} \\
z_{130} &= g\,l_{rp} \\
z_{264} &= -z_3\,z_7\,\dot{\theta}_{h1} - z_4\,z_9\,\dot{\psi}_{h1} \\
z_{265} &= z_6\,z_9\,\dot{\varphi}_{h1} + z_3\,z_4\,z_6\,\dot{\theta}_{h1} + z_3\,z_7\,z_8\,\dot{\varphi}_{h1} - z_3\,z_8\,\dot{\psi}_{h1} - z_6\,z_7\,z_9\,\dot{\psi}_{h1}
\end{aligned}
$$

$$z_{266} = z_3\, z_6\, \dot{\psi}_{h1} + z_8\, z_9\, \dot{\varphi}_{h1} + z_3\, z_4\, z_8\, \dot{\theta}_{h1} - z_3\, z_6\, z_7\, \dot{\varphi}_{h1} - z_7\, z_8\, z_9\, \dot{\psi}_{h1}$$

$$z_{267} = 2u_{h1} + 2z_{89}\, z_{264} + 2z_{90}\, z_{265} + 2z_{91}\, z_{266} - 2u_l$$

$$z_{268} = 2u_l - 2u_{h1} - 2z_{89}\, z_{264} - 2z_{90}\, z_{265} - 2z_{91}\, z_{266}$$

$$z_{269} = z_3\, z_4\, \dot{\psi}_{h1} - z_7\, z_9\, \dot{\theta}_{h1}$$

$$z_{270} = z_3\, z_6\, z_7\, \dot{\psi}_{h1} + z_4\, z_6\, z_9\, \dot{\theta}_{h1} + z_7\, z_8\, z_9\, \dot{\varphi}_{h1} - z_3\, z_6\, \dot{\varphi}_{h1} - z_8\, z_9\, \dot{\psi}_{h1}$$

$$z_{271} = z_6\, z_9\, \dot{\psi}_{h1} + z_3\, z_7\, z_8\, \dot{\psi}_{h1} + z_4\, z_8\, z_9\, \dot{\theta}_{h1} - z_3\, z_8\, \dot{\varphi}_{h1} - z_6\, z_7\, z_9\, \dot{\varphi}_{h1}$$

$$z_{272} = 2v_{h1} + 2z_{89}\, z_{269} + 2z_{90}\, z_{270} + 2z_{91}\, z_{271} - 2v_l$$

$$z_{273} = 2v_l - 2v_{h1} - 2z_{89}\, z_{269} - 2z_{90}\, z_{270} - 2z_{91}\, z_{271}$$

$$z_{274} = z_4\, z_8\, \dot{\varphi}_{h1} - z_6\, z_7\, \dot{\theta}_{h1}$$

$$z_{275} = -z_4\, z_6\, \dot{\varphi}_{h1} - z_7\, z_8\, \dot{\theta}_{h1}$$

$$z_{276} = 2w_l + 2z_{89}\, z_4\, \dot{\theta}_{h1} - 2w_{h1} - 2z_{90}\, z_{274} - 2z_{91}\, z_{275}$$

$$z_{277} = 2w_{h1} + 2z_{90}\, z_{274} + 2z_{91}\, z_{275} - 2w_l - 2z_{89}\, z_4\, \dot{\theta}_{h1}$$

$$z_{278} = \sin(\theta_{h1})$$

$$z_{279} = (z_6\, z_{49}\, \dot{\varphi}_{h1} - z_8\, z_{278}\, \dot{\theta}_{h1})/z_{49}^2$$

$$z_{280} = z_3\, z_7\, \dot{\psi}_{h1} + z_4\, z_9\, \dot{\theta}_{h1}$$

$$z_{281} = z_4\, z_6\, \dot{\theta}_{h1} + z_7\, z_8\, \dot{\varphi}_{h1}$$

$$z_{282} = z_8\, \dot{\theta}_{h1}/z_{49}^2 - z_6\, z_{52}\, \dot{\varphi}_{h1}$$

$$z_{283} = z_3\, z_4\, \dot{\theta}_{h1} - z_7\, z_9\, \dot{\psi}_{h1}$$

$$z_{284} = z_4\, z_8\, \dot{\theta}_{h1} - z_6\, z_7\, \dot{\varphi}_{h1}$$

$$z_{285} = z_3\, z_4\, z_8\, \dot{\varphi}_{h1} - z_3\, z_6\, z_7\, \dot{\theta}_{h1} - z_4\, z_6\, z_9\, \dot{\psi}_{h1}$$

$$z_{286} = z_3\, z_6\, \dot{\varphi}_{h1} + z_8\, z_9\, \dot{\psi}_{h1} - z_3\, z_6\, z_7\, \dot{\psi}_{h1} - z_4\, z_6\, z_9\, \dot{\theta}_{h1} - z_7\, z_8\, z_9\, \dot{\varphi}_{h1}$$

$$z_{287} = z_3\, z_4\, z_6\, \dot{\psi}_{h1} + z_4\, z_8\, z_9\, \dot{\varphi}_{h1} - z_6\, z_7\, z_9\, \dot{\theta}_{h1}$$

$$z_{288} = -z_3\, z_4\, z_6\, \dot{\varphi}_{h1} - z_3\, z_7\, z_8\, \dot{\theta}_{h1} - z_4\, z_8\, z_9\, \dot{\psi}_{h1}$$

$$z_{289} = z_3\, z_8\, \dot{\varphi}_{h1} + z_6\, z_7\, z_9\, \dot{\varphi}_{h1} - z_6\, z_9\, \dot{\psi}_{h1} - z_3\, z_7\, z_8\, \dot{\psi}_{h1} - z_4\, z_8\, z_9\, \dot{\theta}_{h1}$$

$$z_{290} = z_3\, z_8\, \dot{\psi}_{h1} + z_6\, z_7\, z_9\, \dot{\psi}_{h1} - z_6\, z_9\, \dot{\varphi}_{h1} - z_3\, z_4\, z_6\, \dot{\theta}_{h1} - z_3\, z_7\, z_8\, \dot{\varphi}_{h1}$$

$$z_{291} = z_3\, z_4\, z_8\, \dot{\psi}_{h1} - z_4\, z_6\, z_9\, \dot{\varphi}_{h1} - z_7\, z_8\, z_9\, \dot{\theta}_{h1}$$

$$
\begin{aligned}
z_{292} &= 2z_{89}\,(z_5\,z_{51} + z_6\,z_{140}\,)(v_{h1} - v_l\,) + 2z_{89}\,(z_6\,z_{134} - z_{12}\,z_{51}\,)(u_{h1} - u_l\,) \\
&\quad + 2z_{89}\,z_4\,z_8\,z_{133}\,\dot{\varphi}_{h1} + 2z_{90}\,z_{133}\,(z_8\,z_{143}\,\dot{\varphi}_{h1} + z_6\,z_{281} + z_{16}\,z_{282} + z_{54}\,z_{275}\,) \\
&\quad + 2z_{89}\,z_{131}\,(z_8\,z_{134}\,\dot{\varphi}_{h1} + z_6\,z_{283} + z_{12}\,z_{279} - z_{51}\,z_{269}\,) \\
&\quad + 2z_{91}\,z_{133}\,(z_8\,z_{144}\,\dot{\varphi}_{h1} + z_6\,z_{284} - z_{15}\,z_{282} - z_{54}\,z_{274}\,) \\
&\quad + 2z_{90}\,z_{131}\,(z_{11}\,z_{282} + z_{51}\,z_{286} + z_{54}\,z_{266} - z_8\,z_{135}\,\dot{\varphi}_{h1} - z_6\,z_{285} - z_{136}\,z_{279}\,) \\
&\quad + 2z_{91}\,z_{131}\,(z_{51}\,z_{289} + z_{54}\,z_{290} + z_{137}\,z_{282} - z_8\,z_{139}\,\dot{\varphi}_{h1} - z_6\,z_{288} - z_{138}\,z_{279}\,) \\
&\quad - 2z_{89}\,z_4\,z_6\,(w_l - w_{h1}\,) - 2z_{90}\,(z_6\,z_{143} + z_{16}\,z_{54}\,)(w_l - w_{h1}\,) \\
&\quad - 2z_{91}\,(z_6\,z_{144} - z_{15}\,z_{54}\,)(w_l - w_{h1}\,) - 2z_{90}\,(z_6\,z_{135} - z_{11}\,z_{54} - z_{51}\,z_{136}\,)(u_{h1} - u_l\,) \\
&\quad - 2z_{90}\,(z_6\,z_{141} - z_{10}\,z_{51} - z_{14}\,z_{54}\,)(v_{h1} - v_l\,) \\
&\quad - 2z_{91}\,(z_6\,z_{139} - z_{51}\,z_{138} - z_{54}\,z_{137}\,)(u_{h1} - u_l\,) \\
&\quad - 2z_{91}\,(z_6\,z_{142} - z_{11}\,z_{51} - z_{54}\,z_{136}\,)(v_{h1} - v_l\,) - 2z_{89}\,z_6\,z_7\,z_{133}\,\dot{\theta}_{h1} \\
&\quad - 2z_{89}\,z_{132}\,(z_5\,z_{279} - z_8\,z_{140}\,\dot{\varphi}_{h1} - z_6\,z_{280} - z_{51}\,z_{264}\,) \\
&\quad - 2z_{90}\,z_{132}\,(z_8\,z_{141}\,\dot{\varphi}_{h1} + z_6\,z_{287} + z_{10}\,z_{279} - z_{14}\,z_{282} - z_{51}\,z_{265} - z_{54}\,z_{271}\,) \\
&\quad - 2z_{91}\,z_{132}\,(z_8\,z_{142}\,\dot{\varphi}_{h1} + z_6\,z_{291} + z_{11}\,z_{279} - z_{51}\,z_{266} - z_{54}\,z_{286} - z_{136}\,z_{282}\,)
\end{aligned}
$$

$$
z_{293} = (z_6\,z_{278}\,\dot{\theta}_{h1} + z_8\,z_{49}\,\dot{\varphi}_{h1})/z_{49}^2
$$

$$
z_{294} = z_8\,z_{52}\,\dot{\varphi}_{h1} + z_6\,\dot{\theta}_{h1}/z_{49}^2
$$

$$
\begin{aligned}
z_{295} &= 2z_{89}\,z_4\,z_8\,(w_l - w_{h1}\,) + 2z_{91}\,(z_8\,z_{144} + z_{15}\,z_{53}\,)(w_l - w_{h1}\,) \\
&\quad + 2z_{89}\,(z_5\,z_{50} - z_8\,z_{140}\,)(v_{h1} - v_l\,) + 2z_{90}\,(z_8\,z_{143} - z_{16}\,z_{53}\,)(w_l - w_{h1}\,) \\
&\quad + 2z_{90}\,(z_8\,z_{135} + z_{11}\,z_{53} + z_{50}\,z_{136}\,)(u_{h1} - u_l\,) \\
&\quad + 2z_{90}\,(z_8\,z_{141} + z_{10}\,z_{50} + z_{14}\,z_{53}\,)(v_{h1} - v_l\,) \\
&\quad + 2z_{91}\,(z_8\,z_{139} + z_{50}\,z_{138} + z_{53}\,z_{137}\,)(u_{h1} - u_l\,) \\
&\quad + 2z_{91}\,(z_8\,z_{142} + z_{11}\,z_{50} + z_{53}\,z_{136}\,)(v_{h1} - v_l\,) + 2z_{89}\,z_4\,z_6\,z_{133}\,\dot{\varphi}_{h1} \\
&\quad + 2z_{89}\,z_7\,z_8\,z_{133}\,\dot{\theta}_{h1} + 2z_{89}\,z_{131}\,(z_6\,z_{134}\,\dot{\varphi}_{h1} - z_8\,z_{283} - z_{12}\,z_{293} - z_{50}\,z_{269}\,) \\
&\quad + 2z_{91}\,z_{133}\,(z_6\,z_{144}\,\dot{\varphi}_{h1} - z_8\,z_{284} - z_{15}\,z_{294} - z_{53}\,z_{274}\,) \\
&\quad - 2z_{89}\,(z_8\,z_{134} + z_{12}\,z_{50}\,)(u_{h1} - u_l\,) \\
&\quad - 2z_{89}\,z_{132}\,(z_8\,z_{280} - z_6\,z_{140}\,\dot{\varphi}_{h1} - z_5\,z_{293} - z_{50}\,z_{264}\,) \\
&\quad - 2z_{90}\,z_{133}\,(z_8\,z_{281} - z_6\,z_{143}\,\dot{\varphi}_{h1} - z_{16}\,z_{294} - z_{53}\,z_{275}\,) \\
&\quad - 2z_{90}\,z_{131}\,(z_6\,z_{135}\,\dot{\varphi}_{h1} - z_8\,z_{285} - z_{11}\,z_{294} - z_{50}\,z_{286} - z_{53}\,z_{266} - z_{136}\,z_{293}\,) \\
&\quad - 2z_{90}\,z_{132}\,(z_6\,z_{141}\,\dot{\varphi}_{h1} - z_8\,z_{287} - z_{10}\,z_{293} - z_{14}\,z_{294} - z_{50}\,z_{265} - z_{53}\,z_{271}\,) \\
&\quad - 2z_{91}\,z_{131}\,(z_6\,z_{139}\,\dot{\varphi}_{h1} - z_8\,z_{288} - z_{50}\,z_{289} - z_{53}\,z_{290} - z_{137}\,z_{294} - z_{138}\,z_{293}\,) \\
&\quad - 2z_{91}\,z_{132}\,(z_6\,z_{142}\,\dot{\varphi}_{h1} - z_8\,z_{291} - z_{11}\,z_{293} - z_{50}\,z_{266} - z_{53}\,z_{286} - z_{136}\,z_{294}\,)
\end{aligned}
$$

$$
\begin{aligned}
z_{296} &= 2z_{90}\,z_{11}\,(u_{h1} - u_l\,) + 2z_{90}\,z_{14}\,(v_{h1} - v_l\,) + 2z_{91}\,z_{15}\,(w_l - w_{h1}\,) + 2z_{91}\,z_{136}\,(v_{h1} - v_l\,) \\
&\quad + 2z_{91}\,z_{137}\,(u_{h1} - u_l\,) + 2z_{90}\,z_{131}\,z_{266} + 2z_{90}\,z_{132}\,z_{271} + 2z_{90}\,z_{133}\,z_{275} \\
&\quad + 2z_{91}\,z_{131}\,z_{290} + 2z_{91}\,z_{132}\,z_{286} - 2z_{90}\,z_{16}\,(w_l - w_{h1}\,) - 2z_{91}\,z_{133}\,z_{274}
\end{aligned}
$$

$$
\begin{aligned}
z_{297} &= u_{h1}\,z_{267} + u_l\,z_{268} + v_{h1}\,z_{272} + v_l\,z_{273} + w_l\,z_{276} \\
&\quad + w_{h1}\,z_{277} + p_{h1}\,z_{296} + q_{h1}\,z_{295} + r_{h1}\,z_{292}
\end{aligned}
$$

$$
z_{298} = z_{20}\,z_{24}\,\dot{\varphi}_{h2} - z_{22}\,z_{23}\,\dot{\theta}_{h2}
$$

$$
z_{299} = -z_{20}\,z_{22}\,\dot{\varphi}_{h2} - z_{23}\,z_{24}\,\dot{\theta}_{h2}
$$

$$
\begin{aligned}
z_{300} &= 2w_l + 2z_{89}\, z_{20}\, \dot{\theta}_{h2} - 2w_{h2} - 2z_{90}\, z_{298} - 2z_{91}\, z_{299} \\
z_{301} &= 2w_{h2} + 2z_{90}\, z_{298} + 2z_{91}\, z_{299} - 2w_l - 2z_{89}\, z_{20}\, \dot{\theta}_{h2} \\
z_{302} &= -z_{19}\, z_{23}\, \dot{\theta}_{h2} - z_{20}\, z_{25}\, \dot{\psi}_{h2} \\
z_{303} &= \sin(\theta_{h2}) \\
z_{304} &= (z_{22}\, z_{55}\, \dot{\varphi}_{h2} - z_{24}\, z_{303}\, \dot{\theta}_{h2})/z_{55}^2 \\
z_{305} &= z_{19}\, z_{23}\, \dot{\psi}_{h2} + z_{20}\, z_{25}\, \dot{\theta}_{h2} \\
z_{306} &= z_{20}\, z_{22}\, \dot{\theta}_{h2} + z_{23}\, z_{24}\, \dot{\varphi}_{h2} \\
z_{307} &= z_{24}\, \dot{\theta}_{h2}/z_{55}^2 - z_{22}\, z_{58}\, \dot{\varphi}_{h2} \\
z_{308} &= z_{19}\, z_{20}\, \dot{\theta}_{h2} - z_{23}\, z_{25}\, \dot{\psi}_{h2} \\
z_{309} &= z_{19}\, z_{20}\, \dot{\psi}_{h2} - z_{23}\, z_{25}\, \dot{\theta}_{h2} \\
z_{310} &= z_{20}\, z_{24}\, \dot{\theta}_{h2} - z_{22}\, z_{23}\, \dot{\varphi}_{h2} \\
z_{311} &= z_{19}\, z_{20}\, z_{24}\, \dot{\varphi}_{h2} - z_{19}\, z_{22}\, z_{23}\, \dot{\theta}_{h2} - z_{20}\, z_{22}\, z_{25}\, \dot{\psi}_{h2} \\
z_{312} &= z_{19}\, z_{22}\, \dot{\psi}_{h2} + z_{24}\, z_{25}\, \dot{\varphi}_{h2} + z_{19}\, z_{20}\, z_{24}\, \dot{\theta}_{h2} - z_{19}\, z_{22}\, z_{23}\, \dot{\varphi}_{h2} - z_{23}\, z_{24}\, z_{25}\, \dot{\psi}_{h2} \\
z_{313} &= z_{19}\, z_{22}\, \dot{\varphi}_{h2} + z_{24}\, z_{25}\, \dot{\psi}_{h2} - z_{19}\, z_{22}\, z_{23}\, \dot{\psi}_{h2} - z_{20}\, z_{22}\, z_{25}\, \dot{\theta}_{h2} - z_{23}\, z_{24}\, z_{25}\, \dot{\varphi}_{h2} \\
z_{314} &= z_{19}\, z_{20}\, z_{22}\, \dot{\psi}_{h2} + z_{20}\, z_{24}\, z_{25}\, \dot{\varphi}_{h2} - z_{22}\, z_{23}\, z_{25}\, \dot{\theta}_{h2} \\
z_{315} &= z_{22}\, z_{25}\, \dot{\varphi}_{h2} + z_{19}\, z_{20}\, z_{22}\, \dot{\theta}_{h2} + z_{19}\, z_{23}\, z_{24}\, \dot{\varphi}_{h2} - z_{19}\, z_{24}\, \dot{\psi}_{h2} - z_{22}\, z_{23}\, z_{25}\, \dot{\psi}_{h2} \\
z_{316} &= z_{22}\, z_{25}\, \dot{\psi}_{h2} + z_{19}\, z_{23}\, z_{24}\, \dot{\psi}_{h2} + z_{20}\, z_{24}\, z_{25}\, \dot{\theta}_{h2} - z_{19}\, z_{24}\, \dot{\varphi}_{h2} - z_{22}\, z_{23}\, z_{25}\, \dot{\varphi}_{h2} \\
z_{317} &= -z_{19}\, z_{20}\, z_{22}\, \dot{\varphi}_{h2} - z_{19}\, z_{23}\, z_{24}\, \dot{\theta}_{h2} - z_{20}\, z_{24}\, z_{25}\, \dot{\psi}_{h2} \\
z_{318} &= z_{19}\, z_{24}\, \dot{\varphi}_{h2} + z_{22}\, z_{23}\, z_{25}\, \dot{\varphi}_{h2} - z_{22}\, z_{25}\, \dot{\psi}_{h2} - z_{19}\, z_{23}\, z_{24}\, \dot{\psi}_{h2} - z_{20}\, z_{24}\, z_{25}\, \dot{\theta}_{h2} \\
z_{319} &= z_{19}\, z_{24}\, \dot{\psi}_{h2} + z_{22}\, z_{23}\, z_{25}\, \dot{\psi}_{h2} - z_{22}\, z_{25}\, \dot{\varphi}_{h2} - z_{19}\, z_{20}\, z_{22}\, \dot{\theta}_{h2} - z_{19}\, z_{23}\, z_{24}\, \dot{\varphi}_{h2} \\
z_{320} &= z_{19}\, z_{20}\, z_{24}\, \dot{\psi}_{h2} - z_{20}\, z_{22}\, z_{25}\, \dot{\varphi}_{h2} - z_{23}\, z_{24}\, z_{25}\, \dot{\theta}_{h2} \\
z_{321} &= 2z_{90}\,(z_{22}\, z_{149} - z_{27}\, z_{60} - z_{57}\, z_{150})(u_l - u_{h2}) \\
&\quad + 2z_{90}\,(z_{22}\, z_{155} - z_{26}\, z_{57} - z_{30}\, z_{60})(v_l - v_{h2}) \\
&\quad + 2z_{91}\,(z_{22}\, z_{153} - z_{57}\, z_{152} - z_{60}\, z_{151})(u_l - u_{h2}) \\
&\quad + 2z_{91}\,(z_{22}\, z_{156} - z_{27}\, z_{57} - z_{60}\, z_{150})(v_l - v_{h2}) + 2z_{89}\, z_{20}\, z_{24}\, z_{147}\, \dot{\varphi}_{h2} \\
&\quad + 2z_{90}\, z_{147}\,(z_{24}\, z_{157}\, \dot{\varphi}_{h2} + z_{22}\, z_{306} + z_{32}\, z_{307} + z_{60}\, z_{299}) \\
&\quad + 2z_{89}\, z_{145}\,(z_{24}\, z_{148}\, \dot{\varphi}_{h2} + z_{22}\, z_{308} + z_{28}\, z_{304} - z_{57}\, z_{309}) \\
&\quad + 2z_{91}\, z_{147}\,(z_{24}\, z_{158}\, \dot{\varphi}_{h2} + z_{22}\, z_{310} - z_{31}\, z_{307} - z_{60}\, z_{298}) \\
&\quad + 2z_{90}\, z_{145}\,(z_{27}\, z_{307} + z_{57}\, z_{313} + z_{60}\, z_{312} - z_{24}\, z_{149}\, \dot{\varphi}_{h2} - z_{22}\, z_{311} - z_{150}\, z_{304}) \\
&\quad + 2z_{91}\, z_{145}\,(z_{57}\, z_{318} + z_{60}\, z_{319} + z_{151}\, z_{307} - z_{24}\, z_{153}\, \dot{\varphi}_{h2} - z_{22}\, z_{317} - z_{152}\, z_{304}) \\
&\quad - 2z_{89}\, z_{20}\, z_{22}\,(w_l - w_{h2}) - 2z_{89}\,(z_{21}\, z_{57} + z_{22}\, z_{154})(v_l - v_{h2}) \\
&\quad - 2z_{90}\,(z_{22}\, z_{157} + z_{32}\, z_{60})(w_l - w_{h2}) - 2z_{89}\,(z_{22}\, z_{148} - z_{28}\, z_{57})(u_l - u_{h2}) \\
&\quad - 2z_{91}\,(z_{22}\, z_{158} - z_{31}\, z_{60})(w_l - w_{h2}) - 2z_{89}\, z_{22}\, z_{23}\, z_{147}\, \dot{\theta}_{h2} \\
&\quad - 2z_{89}\, z_{146}\,(z_{21}\, z_{304} - z_{24}\, z_{154}\, \dot{\varphi}_{h2} - z_{22}\, z_{305} - z_{57}\, z_{302}) \\
&\quad - 2z_{90}\, z_{146}\,(z_{24}\, z_{155}\, \dot{\varphi}_{h2} + z_{22}\, z_{314} + z_{26}\, z_{304} - z_{30}\, z_{307} - z_{57}\, z_{315} - z_{60}\, z_{316}) \\
&\quad - 2z_{91}\, z_{146}\,(z_{24}\, z_{156}\, \dot{\varphi}_{h2} + z_{22}\, z_{320} + z_{27}\, z_{304} - z_{57}\, z_{312} - z_{60}\, z_{313} - z_{150}\, z_{307})
\end{aligned}
$$

$$
\begin{aligned}
z_{322} &= (z_{22}\, z_{303}\, \dot{\theta}_{h2} + z_{24}\, z_{55}\, \dot{\varphi}_{h2})/z_{55}^2 \\
z_{323} &= z_{24}\, z_{58}\, \dot{\varphi}_{h2} + z_{22}\, \dot{\theta}_{h2}/z_{55}^2 \\
z_{324} &= 2z_{89}\, z_{20}\, z_{24}\, (w_l - w_{h2}) + 2z_{89}\, (z_{24}\, z_{148} + z_{28}\, z_{56})(u_l - u_{h2}) \\
&\quad + 2z_{91}\, (z_{24}\, z_{158} + z_{31}\, z_{59})(w_l - w_{h2}) + 2z_{90}\, (z_{24}\, z_{157} - z_{32}\, z_{59})(w_l - w_{h2}) \\
&\quad + 2z_{89}\, z_{20}\, z_{22}\, z_{147}\, \dot{\varphi}_{h2} + 2z_{89}\, z_{23}\, z_{24}\, z_{147}\, \dot{\theta}_{h2} \\
&\quad + 2z_{89}\, z_{145}\, (z_{22}\, z_{148}\, \dot{\varphi}_{h2} - z_{24}\, z_{308} - z_{28}\, z_{322} - z_{56}\, z_{309}) \\
&\quad + 2z_{91}\, z_{147}\, (z_{22}\, z_{158}\, \dot{\varphi}_{h2} - z_{24}\, z_{310} - z_{31}\, z_{323} - z_{59}\, z_{298}) \\
&\quad - 2z_{89}\, (z_{21}\, z_{56} - z_{24}\, z_{154})(v_l - v_{h2}) - 2z_{90}\, (z_{24}\, z_{149} + z_{27}\, z_{59} + z_{56}\, z_{150})(u_l - u_{h2}) \\
&\quad - 2z_{90}\, (z_{24}\, z_{155} + z_{26}\, z_{56} + z_{30}\, z_{59})(v_l - v_{h2}) \\
&\quad - 2z_{91}\, (z_{24}\, z_{153} + z_{56}\, z_{152} + z_{59}\, z_{151})(u_l - u_{h2}) \\
&\quad - 2z_{91}\, (z_{24}\, z_{156} + z_{27}\, z_{56} + z_{59}\, z_{150})(v_l - v_{h2}) \\
&\quad - 2z_{89}\, z_{146}\, (z_{24}\, z_{305} - z_{22}\, z_{154}\, \dot{\varphi}_{h2} - z_{21}\, z_{322} - z_{56}\, z_{302}) \\
&\quad - 2z_{90}\, z_{147}\, (z_{24}\, z_{306} - z_{22}\, z_{157}\, \dot{\varphi}_{h2} - z_{32}\, z_{323} - z_{59}\, z_{299}) \\
&\quad - 2z_{90}\, z_{145}\, (z_{22}\, z_{149}\, \dot{\varphi}_{h2} - z_{24}\, z_{311} - z_{27}\, z_{323} - z_{56}\, z_{313} - z_{59}\, z_{312} - z_{150}\, z_{322}) \\
&\quad - 2z_{90}\, z_{146}\, (z_{22}\, z_{155}\, \dot{\varphi}_{h2} - z_{24}\, z_{314} - z_{26}\, z_{322} - z_{30}\, z_{323} - z_{56}\, z_{315} - z_{59}\, z_{316}) \\
&\quad - 2z_{91}\, z_{145}\, (z_{22}\, z_{153}\, \dot{\varphi}_{h2} - z_{24}\, z_{317} - z_{56}\, z_{318} - z_{59}\, z_{319} - z_{151}\, z_{323} - z_{152}\, z_{322}) \\
&\quad - 2z_{91}\, z_{146}\, (z_{22}\, z_{156}\, \dot{\varphi}_{h2} - z_{24}\, z_{320} - z_{27}\, z_{322} - z_{56}\, z_{312} - z_{59}\, z_{313} - z_{150}\, z_{323}) \\
z_{325} &= 2z_{91}\, z_{31}\, (w_l - w_{h2}) + 2z_{90}\, z_{145}\, z_{312} + 2z_{90}\, z_{146}\, z_{316} + 2z_{90}\, z_{147}\, z_{299} \\
&\quad + 2z_{91}\, z_{145}\, z_{319} + 2z_{91}\, z_{146}\, z_{313} - 2z_{90}\, z_{27}\, (u_l - u_{h2}) - 2z_{90}\, z_{30}\, (v_l - v_{h2}) \\
&\quad - 2z_{90}\, z_{32}\, (w_l - w_{h2}) - 2z_{91}\, z_{150}\, (v_l - v_{h2}) - 2z_{91}\, z_{151}\, (u_l - u_{h2}) - 2z_{91}\, z_{147}\, z_{298} \\
z_{326} &= 2u_l - 2u_{h2} - 2z_{89}\, z_{302} - 2z_{90}\, z_{315} - 2z_{91}\, z_{312} \\
z_{327} &= 2u_{h2} + 2z_{89}\, z_{302} + 2z_{90}\, z_{315} + 2z_{91}\, z_{312} - 2u_l \\
z_{328} &= z_{19}\, z_{22}\, z_{23}\, \dot{\psi}_{h2} + z_{20}\, z_{22}\, z_{25}\, \dot{\theta}_{h2} + z_{23}\, z_{24}\, z_{25}\, \dot{\varphi}_{h2} - z_{19}\, z_{22}\, \dot{\varphi}_{h2} - z_{24}\, z_{25}\, \dot{\psi}_{h2} \\
z_{329} &= 2v_l - 2v_{h2} - 2z_{89}\, z_{309} - 2z_{90}\, z_{328} - 2z_{91}\, z_{316} \\
z_{330} &= 2v_{h2} + 2z_{89}\, z_{309} + 2z_{90}\, z_{328} + 2z_{91}\, z_{316} - 2v_l \\
z_{331} &= p_{h2}\, z_{325} + q_{h2}\, z_{324} + r_{h2}\, z_{321} + u_l\, z_{326} + v_l\, z_{329} \\
&\quad + w_l\, z_{300} + u_{h2}\, z_{327} + v_{h2}\, z_{330} + w_{h2}\, z_{301} \\
z_{332} &= -z_{35}\, z_{39}\, \dot{\theta}_{h3} - z_{36}\, z_{41}\, \dot{\psi}_{h3} \\
z_{333} &= z_{38}\, z_{41}\, \dot{\varphi}_{h3} + z_{35}\, z_{36}\, z_{38}\, \dot{\theta}_{h3} + z_{35}\, z_{39}\, z_{40}\, \dot{\varphi}_{h3} - z_{35}\, z_{40}\, \dot{\psi}_{h3} - z_{38}\, z_{39}\, z_{41}\, \dot{\psi}_{h3} \\
z_{334} &= z_{35}\, z_{38}\, \dot{\psi}_{h3} + z_{40}\, z_{41}\, \dot{\varphi}_{h3} + z_{35}\, z_{36}\, z_{40}\, \dot{\theta}_{h3} - z_{35}\, z_{38}\, z_{39}\, \dot{\varphi}_{h3} - z_{39}\, z_{40}\, z_{41}\, \dot{\psi}_{h3} \\
z_{335} &= 2u_{h3} + 2z_{89}\, z_{332} + 2z_{90}\, z_{333} + 2z_{91}\, z_{334} - 2u_l \\
z_{336} &= 2u_l - 2u_{h3} - 2z_{89}\, z_{332} - 2z_{90}\, z_{333} - 2z_{91}\, z_{334} \\
z_{337} &= z_{35}\, z_{36}\, \dot{\psi}_{h3} - z_{39}\, z_{41}\, \dot{\theta}_{h3} \\
z_{338} &= z_{35}\, z_{38}\, z_{39}\, \dot{\psi}_{h3} + z_{36}\, z_{38}\, z_{41}\, \dot{\theta}_{h3} + z_{39}\, z_{40}\, z_{41}\, \dot{\varphi}_{h3} - z_{35}\, z_{38}\, \dot{\varphi}_{h3} - z_{40}\, z_{41}\, \dot{\psi}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
z_{339} &= z_{38}\, z_{41}\, \dot{\psi}_{h3} + z_{35}\, z_{39}\, z_{40}\, \dot{\psi}_{h3} + z_{36}\, z_{40}\, z_{41}\, \dot{\theta}_{h3} - z_{35}\, z_{40}\, \dot{\varphi}_{h3} - z_{38}\, z_{39}\, z_{41}\, \dot{\varphi}_{h3} \\
z_{340} &= 2v_{h3} + 2z_{89}\, z_{337} + 2z_{90}\, z_{338} + 2z_{91}\, z_{339} - 2v_l \\
z_{341} &= 2v_l - 2v_{h3} - 2z_{89}\, z_{337} - 2z_{90}\, z_{338} - 2z_{91}\, z_{339} \\
z_{342} &= z_{36}\, z_{40}\, \dot{\varphi}_{h3} - z_{38}\, z_{39}\, \dot{\theta}_{h3} \\
z_{343} &= -z_{36}\, z_{38}\, \dot{\varphi}_{h3} - z_{39}\, z_{40}\, \dot{\theta}_{h3} \\
z_{344} &= 2w_{h3} + 2z_{90}\, z_{342} + 2z_{91}\, z_{343} - 2w_l - 2z_{89}\, z_{36}\, \dot{\theta}_{h3} \\
z_{345} &= 2w_l + 2z_{89}\, z_{36}\, \dot{\theta}_{h3} - 2w_{h3} - 2z_{90}\, z_{342} - 2z_{91}\, z_{343} \\
z_{346} &= \sin(\theta_{h3}) \\
z_{347} &= (z_{38}\, z_{61}\, \dot{\varphi}_{h3} - z_{40}\, z_{346}\, \dot{\theta}_{h3})/z_{61}^2 \\
z_{348} &= z_{35}\, z_{39}\, \dot{\psi}_{h3} + z_{36}\, z_{41}\, \dot{\theta}_{h3} \\
z_{349} &= z_{36}\, z_{38}\, \dot{\theta}_{h3} + z_{39}\, z_{40}\, \dot{\varphi}_{h3} \\
z_{350} &= z_{40}\, \dot{\theta}_{h3}/z_{61}^2 - z_{38}\, z_{64}\, \dot{\varphi}_{h3} \\
z_{351} &= z_{35}\, z_{36}\, \dot{\theta}_{h3} - z_{39}\, z_{41}\, \dot{\psi}_{h3} \\
z_{352} &= z_{36}\, z_{40}\, \dot{\theta}_{h3} - z_{38}\, z_{39}\, \dot{\varphi}_{h3} \\
z_{353} &= z_{35}\, z_{36}\, z_{40}\, \dot{\varphi}_{h3} - z_{35}\, z_{38}\, z_{39}\, \dot{\theta}_{h3} - z_{36}\, z_{38}\, z_{41}\, \dot{\psi}_{h3} \\
z_{354} &= z_{35}\, z_{38}\, \dot{\varphi}_{h3} + z_{40}\, z_{41}\, \dot{\psi}_{h3} - z_{35}\, z_{38}\, z_{39}\, \dot{\psi}_{h3} - z_{36}\, z_{38}\, z_{41}\, \dot{\theta}_{h3} - z_{39}\, z_{40}\, z_{41}\, \dot{\varphi}_{h3} \\
z_{355} &= z_{35}\, z_{36}\, z_{38}\, \dot{\psi}_{h3} + z_{36}\, z_{40}\, z_{41}\, \dot{\varphi}_{h3} - z_{38}\, z_{39}\, z_{41}\, \dot{\theta}_{h3} \\
z_{356} &= -z_{35}\, z_{36}\, z_{38}\, \dot{\varphi}_{h3} - z_{35}\, z_{39}\, z_{40}\, \dot{\theta}_{h3} - z_{36}\, z_{40}\, z_{41}\, \dot{\psi}_{h3} \\
z_{357} &= z_{35}\, z_{40}\, \dot{\varphi}_{h3} + z_{38}\, z_{39}\, z_{41}\, \dot{\varphi}_{h3} - z_{38}\, z_{41}\, \dot{\psi}_{h3} - z_{35}\, z_{39}\, z_{40}\, \dot{\psi}_{h3} - z_{36}\, z_{40}\, z_{41}\, \dot{\theta}_{h3} \\
z_{358} &= z_{35}\, z_{40}\, \dot{\psi}_{h3} + z_{38}\, z_{39}\, z_{41}\, \dot{\psi}_{h3} - z_{38}\, z_{41}\, \dot{\varphi}_{h3} - z_{35}\, z_{36}\, z_{38}\, \dot{\theta}_{h3} - z_{35}\, z_{39}\, z_{40}\, \dot{\varphi}_{h3} \\
z_{359} &= z_{35}\, z_{36}\, z_{40}\, \dot{\psi}_{h3} - z_{36}\, z_{38}\, z_{41}\, \dot{\varphi}_{h3} - z_{39}\, z_{40}\, z_{41}\, \dot{\theta}_{h3} \\
z_{360} &= 2z_{89}\, z_{36}\, z_{38}\, (w_{h3} - w_l) + 2z_{89}\, (z_{37}\, z_{63} + z_{38}\, z_{168})(v_{h3} - v_l) \\
&\quad + 2z_{90}\, (z_{38}\, z_{171} + z_{48}\, z_{66})(w_{h3} - w_l) + 2z_{89}\, (z_{38}\, z_{162} - z_{44}\, z_{63})(u_{h3} - u_l) \\
&\quad + 2z_{91}\, (z_{38}\, z_{172} - z_{47}\, z_{66})(w_{h3} - w_l) + 2z_{89}\, z_{36}\, z_{40}\, z_{161}\, \dot{\varphi}_{h3} \\
&\quad + 2z_{90}\, z_{161}\, (z_{40}\, z_{171}\, \dot{\varphi}_{h3} + z_{38}\, z_{349} + z_{48}\, z_{350} + z_{66}\, z_{343}) \\
&\quad + 2z_{89}\, z_{159}\, (z_{40}\, z_{162}\, \dot{\varphi}_{h3} + z_{38}\, z_{351} + z_{44}\, z_{347} - z_{63}\, z_{337}) \\
&\quad + 2z_{91}\, z_{161}\, (z_{40}\, z_{172}\, \dot{\varphi}_{h3} + z_{38}\, z_{352} - z_{47}\, z_{350} - z_{66}\, z_{342}) \\
&\quad + 2z_{90}\, z_{159}\, (z_{43}\, z_{350} + z_{63}\, z_{354} + z_{66}\, z_{334} - z_{40}\, z_{163}\, \dot{\varphi}_{h3} - z_{38}\, z_{353} - z_{164}\, z_{347}) \\
&\quad + 2z_{91}\, z_{159}\, (z_{63}\, z_{357} + z_{66}\, z_{358} + z_{165}\, z_{350} - z_{40}\, z_{167}\, \dot{\varphi}_{h3} - z_{38}\, z_{356} - z_{166}\, z_{347}) \\
&\quad - 2z_{90}\, (z_{38}\, z_{163} - z_{43}\, z_{66} - z_{63}\, z_{164})(u_{h3} - u_l) \\
&\quad - 2z_{90}\, (z_{38}\, z_{169} - z_{42}\, z_{63} - z_{46}\, z_{66})(v_{h3} - v_l) \\
&\quad - 2z_{91}\, (z_{38}\, z_{167} - z_{63}\, z_{166} - z_{66}\, z_{165})(u_{h3} - u_l) \\
&\quad - 2z_{91}\, (z_{38}\, z_{170} - z_{43}\, z_{63} - z_{66}\, z_{164})(v_{h3} - v_l) - 2z_{89}\, z_{38}\, z_{39}\, z_{161}\, \dot{\theta}_{h3} \\
&\quad - 2z_{89}\, z_{160}\, (z_{37}\, z_{347} - z_{40}\, z_{168}\, \dot{\varphi}_{h3} - z_{38}\, z_{348} - z_{63}\, z_{332}) \\
&\quad - 2z_{90}\, z_{160}\, (z_{40}\, z_{169}\, \dot{\varphi}_{h3} + z_{38}\, z_{355} + z_{42}\, z_{347} - z_{46}\, z_{350} - z_{63}\, z_{333} - z_{66}\, z_{339}) \\
&\quad - 2z_{91}\, z_{160}\, (z_{40}\, z_{170}\, \dot{\varphi}_{h3} + z_{38}\, z_{359} + z_{43}\, z_{347} - z_{63}\, z_{334} - z_{66}\, z_{354} - z_{164}\, z_{350})
\end{aligned}
$$

$$z_{361} = (z_{38}\, z_{346}\, \dot{\theta}_{h3} + z_{40}\, z_{61}\, \dot{\varphi}_{h3})/z_{61}^2$$

$$z_{362} = z_{40}\, z_{64}\, \dot{\varphi}_{h3} + z_{38}\, \dot{\theta}_{h3}/z_{61}^2$$

$$\begin{aligned} z_{363} = {} & 2z_{89}\,(z_{37}\, z_{62} - z_{40}\, z_{168}\,)(v_{h3} - v_l\,) + 2z_{90}\,(z_{40}\, z_{163} + z_{43}\, z_{65} + z_{62}\, z_{164}\,)(u_{h3} - u_l\,) \\ & + 2z_{90}\,(z_{40}\, z_{169} + z_{42}\, z_{62} + z_{46}\, z_{65}\,)(v_{h3} - v_l\,) \\ & + 2z_{91}\,(z_{40}\, z_{167} + z_{62}\, z_{166} + z_{65}\, z_{165}\,)(u_{h3} - u_l\,) \\ & + 2z_{91}\,(z_{40}\, z_{170} + z_{43}\, z_{62} + z_{65}\, z_{164}\,)(v_{h3} - v_l\,) + 2z_{89}\, z_{36}\, z_{38}\, z_{161}\, \dot{\varphi}_{h3} \\ & + 2z_{89}\, z_{39}\, z_{40}\, z_{161}\, \dot{\theta}_{h3} + 2z_{89}\, z_{159}\,(z_{38}\, z_{162}\, \dot{\varphi}_{h3} - z_{40}\, z_{351} - z_{44}\, z_{361} - z_{62}\, z_{337}\,) \\ & + 2z_{91}\, z_{161}\,(z_{38}\, z_{172}\, \dot{\varphi}_{h3} - z_{40}\, z_{352} - z_{47}\, z_{362} - z_{65}\, z_{342}\,) \\ & - 2z_{89}\, z_{36}\, z_{40}\,(w_{h3} - w_l\,) - 2z_{89}\,(z_{40}\, z_{162} + z_{44}\, z_{62}\,)(u_{h3} - u_l\,) \\ & - 2z_{91}\,(z_{40}\, z_{172} + z_{47}\, z_{65}\,)(w_{h3} - w_l\,) - 2z_{90}\,(z_{40}\, z_{171} - z_{48}\, z_{65}\,)(w_{h3} - w_l\,) \\ & - 2z_{89}\, z_{160}\,(z_{40}\, z_{348} - z_{38}\, z_{168}\, \dot{\varphi}_{h3} - z_{37}\, z_{361} - z_{62}\, z_{332}\,) \\ & - 2z_{90}\, z_{161}\,(z_{40}\, z_{349} - z_{38}\, z_{171}\, \dot{\varphi}_{h3} - z_{48}\, z_{362} - z_{65}\, z_{343}\,) \\ & - 2z_{90}\, z_{159}\,(z_{38}\, z_{163}\, \dot{\varphi}_{h3} - z_{40}\, z_{353} - z_{43}\, z_{362} - z_{62}\, z_{354} - z_{65}\, z_{334} - z_{164}\, z_{361}\,) \\ & - 2z_{90}\, z_{160}\,(z_{38}\, z_{169}\, \dot{\varphi}_{h3} - z_{40}\, z_{355} - z_{42}\, z_{361} - z_{46}\, z_{362} - z_{62}\, z_{333} - z_{65}\, z_{339}\,) \\ & - 2z_{91}\, z_{159}\,(z_{38}\, z_{167}\, \dot{\varphi}_{h3} - z_{40}\, z_{356} - z_{62}\, z_{357} - z_{65}\, z_{358} - z_{165}\, z_{362} - z_{166}\, z_{361}\,) \\ & - 2z_{91}\, z_{160}\,(z_{38}\, z_{170}\, \dot{\varphi}_{h3} - z_{40}\, z_{359} - z_{43}\, z_{361} - z_{62}\, z_{334} - z_{65}\, z_{354} - z_{164}\, z_{362}\,) \end{aligned}$$

$$\begin{aligned} z_{364} = {} & 2z_{90}\, z_{43}\,(u_{h3} - u_l\,) + 2z_{90}\, z_{46}\,(v_{h3} - v_l\,) + 2z_{90}\, z_{48}\,(w_{h3} - w_l\,) + 2z_{91}\, z_{164}\,(v_{h3} - v_l\,) \\ & + 2z_{91}\, z_{165}\,(u_{h3} - u_l\,) + 2z_{90}\, z_{159}\, z_{334} + 2z_{90}\, z_{160}\, z_{339} + 2z_{90}\, z_{161}\, z_{343} \\ & + 2z_{91}\, z_{159}\, z_{358} + 2z_{91}\, z_{160}\, z_{354} - 2z_{91}\, z_{47}\,(w_{h3} - w_l\,) - 2z_{91}\, z_{161}\, z_{342} \end{aligned}$$

$$\begin{aligned} z_{365} = {} & u_{h3}\, z_{335} + v_{h3}\, z_{340} + w_{h3}\, z_{344} + p_{h3}\, z_{364} + q_{h3}\, z_{363} \\ & + r_{h3}\, z_{360} + u_l\, z_{336} + v_l\, z_{341} + w_l\, z_{345} \end{aligned}$$

$$z_{366} = (z_{202}\, z_{365} + z_{204}\, z_{297} - z_{207}\, z_{331}\,)/z_{203}$$

$$z_{367} = (z_{201}\, z_{365} + z_{205}\, z_{297} - z_{208}\, z_{331}\,)/z_{203}$$

$$z_{368} = (z_{200}\, z_{365} + z_{206}\, z_{297} - z_{209}\, z_{331}\,)/z_{203}$$

$$\begin{aligned} z_{369} = {} & z_{130}\, z_{246} + F_{h1,3}^{MR} z_{11} + F_{h1,2}^{TR} z_{10} + z_{129}\, z_5\, z_7 \\ & + z_{128}\,(z_5\, z_7 - z_{10}\, z_{15} - z_{11}\, z_{16}\,) - z_{129}\, z_{10}\, z_{15} - z_{129}\, z_{11}\, z_{16} \end{aligned}$$

$$\begin{aligned} z_{370} = {} & z_{130}\, z_{247} + F_{h1,3}^{MR} z_{14} + F_{h1,2}^{TR} z_{13} + z_{129}\, z_7\, z_{12} \\ & + z_{128}\,(z_7\, z_{12} - z_{13}\, z_{15} - z_{14}\, z_{16}\,) - z_{129}\, z_{13}\, z_{15} - z_{129}\, z_{14}\, z_{16} \end{aligned}$$

$$z_{371} = z_{130}\, z_{248} + F_{h1,3}^{MR} z_{16} + F_{h1,2}^{TR} z_{15} - z_{129}\, z_7^2 - z_{129}\, z_{15}^2 - z_{129}\, z_{16}^2 - z_{128}\,(z_7^2 + z_{15}^2 + z_{16}^2)$$

$$z_{372} = z_{82}\, z_{129}$$

$$z_{373} = z_{81}\, z_{129}$$

$$z_{374} = T_{h1,1}^{MR} + z_{81}\, F_{h1,3}^{MR} + z_{130}\, z_{251} + z_{372}\, z_{15} - z_{88}\, F_{h1,2}^{TR} - z_{373}\, z_{16} - z_{128}\,(z_{84}\, z_{16} - z_{85}\, z_{15}\,)$$

$$z_{375} = z_{80}\, z_{129}$$

$$z_{376} = T_{h1,2}^{MR} + T_{h1,2}^{TR} + z_{130}\, z_{250} + z_{372}\, z_7 + z_{375}\, z_{16} + z_{128}\,(z_{83}\, z_{16} + z_{85}\, z_7\,) - z_{80}\, F_{h1,3}^{MR}$$

$$z_{377} = T^{MR}_{h1,3} + z_{86}\, F^{TR}_{h1,2} + z_{130}\, z_{249} - z_{128}\,(z_{83}\, z_{15} + z_{84}\, z_7) - z_{129}\,(z_{80}\, z_{15} + z_{81}\, z_7)$$

$$\begin{aligned} z_{378} &= F^{MR}_{h2,3} z_{27} + F^{TR}_{h2,2} z_{26} + z_{129}\, z_{21}\, z_{23} + z_{128}\,(z_{21}\, z_{23} - z_{26}\, z_{31} - z_{27}\, z_{32}) \\ &\quad - z_{130}\, z_{256} - z_{129}\, z_{26}\, z_{31} - z_{129}\, z_{27}\, z_{32} \end{aligned}$$

$$\begin{aligned} z_{379} &= F^{MR}_{h2,3} z_{30} + F^{TR}_{h2,2} z_{29} + z_{129}\, z_{23}\, z_{28} + z_{128}\,(z_{23}\, z_{28} - z_{29}\, z_{31} - z_{30}\, z_{32}) \\ &\quad - z_{130}\, z_{257} - z_{129}\, z_{29}\, z_{31} - z_{129}\, z_{30}\, z_{32} \end{aligned}$$

$$z_{380} = F^{MR}_{h2,3} z_{32} + F^{TR}_{h2,2} z_{31} - z_{130}\, z_{252} - z_{129}\, z^2_{23} - z_{129}\, z^2_{31} - z_{129}\, z^2_{32} - z_{128}\,(z^2_{23} + z^2_{31} + z^2_{32})$$

$$z_{381} = T^{MR}_{h2,1} + z_{81}\, F^{MR}_{h2,3} + z_{372}\, z_{31} - z_{88}\, F^{TR}_{h2,2} - z_{130}\, z_{255} - z_{373}\, z_{32} - z_{128}\,(z_{84}\, z_{32} - z_{85}\, z_{31})$$

$$z_{382} = T^{MR}_{h2,2} + T^{TR}_{h2,2} + z_{372}\, z_{23} + z_{375}\, z_{32} + z_{128}\,(z_{83}\, z_{32} + z_{85}\, z_{23}) - z_{80}\, F^{MR}_{h2,3} - z_{130}\, z_{254}$$

$$z_{383} = T^{MR}_{h2,3} + z_{86}\, F^{TR}_{h2,2} - z_{130}\, z_{253} - z_{128}\,(z_{83}\, z_{31} + z_{84}\, z_{23}) - z_{129}\,(z_{80}\, z_{31} + z_{81}\, z_{23})$$

$$\begin{aligned} z_{384} &= z_{130}\, z_{258} + F^{MR}_{h3,3} z_{43} + F^{TR}_{h3,2} z_{42} + z_{129}\, z_{37}\, z_{39} \\ &\quad + z_{128}\,(z_{37}\, z_{39} - z_{42}\, z_{47} - z_{43}\, z_{48}) - z_{129}\, z_{42}\, z_{47} - z_{129}\, z_{43}\, z_{48} \end{aligned}$$

$$\begin{aligned} z_{385} &= z_{130}\, z_{259} + F^{MR}_{h3,3} z_{46} + F^{TR}_{h3,2} z_{45} + z_{129}\, z_{39}\, z_{44} \\ &\quad + z_{128}\,(z_{39}\, z_{44} - z_{45}\, z_{47} - z_{46}\, z_{48}) - z_{129}\, z_{45}\, z_{47} - z_{129}\, z_{46}\, z_{48} \end{aligned}$$

$$z_{386} = z_{130}\, z_{260} + F^{MR}_{h3,3} z_{48} + F^{TR}_{h3,2} z_{47} - z_{129}\, z^2_{39} - z_{129}\, z^2_{47} - z_{129}\, z^2_{48} - z_{128}\,(z^2_{39} + z^2_{47} + z^2_{48})$$

$$z_{387} = T^{MR}_{h3,1} + z_{81}\, F^{MR}_{h3,3} + z_{130}\, z_{263} + z_{372}\, z_{47} - z_{88}\, F^{TR}_{h3,2} - z_{373}\, z_{48} - z_{128}\,(z_{84}\, z_{48} - z_{85}\, z_{47})$$

$$z_{388} = T^{MR}_{h3,2} + T^{TR}_{h3,2} + z_{130}\, z_{262} + z_{372}\, z_{39} + z_{375}\, z_{48} + z_{128}\,(z_{83}\, z_{48} + z_{85}\, z_{39}) - z_{80}\, F^{MR}_{h3,3}$$

$$z_{389} = T^{MR}_{h3,3} + z_{86}\, F^{TR}_{h3,2} + z_{130}\, z_{261} - z_{128}\,(z_{83}\, z_{47} + z_{84}\, z_{39}) - z_{129}\,(z_{80}\, z_{47} + z_{81}\, z_{39})$$

$$z_{390} = I^F_{11}\, p_{h1}$$

$$z_{391} = I^F_{22}\, q_{h1}$$

$$z_{392} = I^F_{33}\, r_{h1}$$

$$z_{393} = p_{h1}\, z_{391} - q_{h1}\, z_{390}$$

$$z_{394} = r_{h1}\, z_{390} - p_{h1}\, z_{392}$$

$$z_{395} = q_{h1}\, z_{392} - r_{h1}\, z_{391}$$

$$z_{396} = I^{MR}_{11}\, p_{h1}$$

$$z_{397} = I^{MR}_{22}\, q_{h1}$$

$$z_{398} = I^{MR}_{33}\, z_{67}$$

$$z_{399} = I^{MR}_{11}\, z_{68}$$

$$z_{400} = I^{MR}_{22}\, z_{69}$$

$$z_{401} = p_{h1}\, z_{397} - q_{h1}\, z_{396}$$
$$z_{402} = z_{67}\, z_{396} - p_{h1}\, z_{398}$$
$$z_{403} = q_{h1}\, z_{398} - z_{67}\, z_{397}$$
$$z_{404} = I_{11}^{F}\, p_{h2}$$
$$z_{405} = I_{22}^{F}\, q_{h2}$$
$$z_{406} = I_{33}^{F}\, r_{h2}$$
$$z_{407} = p_{h2}\, z_{405} - q_{h2}\, z_{404}$$
$$z_{408} = r_{h2}\, z_{404} - p_{h2}\, z_{406}$$
$$z_{409} = q_{h2}\, z_{406} - r_{h2}\, z_{405}$$
$$z_{410} = I_{11}^{MR}\, p_{h2}$$
$$z_{411} = I_{22}^{MR}\, q_{h2}$$
$$z_{412} = I_{33}^{MR}\, z_{70}$$
$$z_{413} = I_{11}^{MR}\, z_{71}$$
$$z_{414} = I_{22}^{MR}\, z_{72}$$
$$z_{415} = p_{h2}\, z_{411} - q_{h2}\, z_{410}$$
$$z_{416} = z_{70}\, z_{410} - p_{h2}\, z_{412}$$
$$z_{417} = q_{h2}\, z_{412} - z_{70}\, z_{411}$$
$$z_{418} = I_{11}^{F}\, p_{h3}$$
$$z_{419} = I_{22}^{F}\, q_{h3}$$
$$z_{420} = I_{33}^{F}\, r_{h3}$$
$$z_{421} = p_{h3}\, z_{419} - q_{h3}\, z_{418}$$
$$z_{422} = r_{h3}\, z_{418} - p_{h3}\, z_{420}$$
$$z_{423} = q_{h3}\, z_{420} - r_{h3}\, z_{419}$$
$$z_{424} = I_{11}^{MR}\, p_{h3}$$
$$z_{425} = I_{22}^{MR}\, q_{h3}$$
$$z_{426} = I_{33}^{MR}\, z_{73}$$
$$z_{427} = I_{11}^{MR}\, z_{74}$$
$$z_{428} = I_{22}^{MR}\, z_{75}$$
$$z_{429} = p_{h3}\, z_{425} - q_{h3}\, z_{424}$$

$$z_{430} = z_{73}\, z_{424} - p_{h3}\, z_{426}$$

$$z_{431} = q_{h3}\, z_{426} - z_{73}\, z_{425}$$

$$z_{432} = m_F\,(z_{83}\, z_{10} - z_{84}\, z_5\,) + m_{MR}\,(z_{80}\, z_{10} - z_{81}\, z_5\,)$$

$$z_{433} = z_{76}\,(z_5\, z_7 - z_{10}\, z_{15} - z_{11}\, z_{16}\,)$$

$$z_{434} = -m_F\,(z_{83}\, z_{11} - z_{85}\, z_5\,) - m_{MR}\,(z_{80}\, z_{11} - z_{82}\, z_5\,)$$

$$z_{435} = z_{76}\,(z_5^2 + z_{10}^2 + z_{11}^2)$$

$$z_{436} = z_{76}\,(z_5\, z_{12} + z_{10}\, z_{13} + z_{11}\, z_{14}\,)$$

$$z_{437} = m_F\,(z_{84}\, z_{11} - z_{85}\, z_{10}\,) + m_{MR}\,(z_{81}\, z_{11} - z_{82}\, z_{10}\,)$$

$$z_{438} = m_F\,(z_5\, z_{95} + z_{10}\, z_{96} + z_{11}\, z_{97}\,) + m_{MR}\,(z_5\, z_{92} + z_{10}\, z_{93} + z_{11}\, z_{94}\,)$$

$$z_{439} = m_F\,(z_{83}\, z_{13} - z_{84}\, z_{12}\,) + m_{MR}\,(z_{80}\, z_{13} - z_{81}\, z_{12}\,)$$

$$z_{440} = z_{76}\,(z_7\, z_{12} - z_{13}\, z_{15} - z_{14}\, z_{16}\,)$$

$$z_{441} = -m_F\,(z_{83}\, z_{14} - z_{85}\, z_{12}\,) - m_{MR}\,(z_{80}\, z_{14} - z_{82}\, z_{12}\,)$$

$$z_{442} = z_{76}\,(z_{12}^2 + z_{13}^2 + z_{14}^2)$$

$$z_{443} = m_F\,(z_{84}\, z_{14} - z_{85}\, z_{13}\,) + m_{MR}\,(z_{81}\, z_{14} - z_{82}\, z_{13}\,)$$

$$z_{444} = m_F\,(z_{12}\, z_{95} + z_{13}\, z_{96} + z_{14}\, z_{97}\,) + m_{MR}\,(z_{12}\, z_{92} + z_{13}\, z_{93} + z_{14}\, z_{94}\,)$$

$$z_{445} = m_F\,(z_{83}\, z_{15} + z_{84}\, z_7\,) + m_{MR}\,(z_{80}\, z_{15} + z_{81}\, z_7\,)$$

$$z_{446} = z_{76}\,(z_7^2 + z_{15}^2 + z_{16}^2)$$

$$z_{447} = -m_F\,(z_{83}\, z_{16} + z_{85}\, z_7\,) - m_{MR}\,(z_{80}\, z_{16} + z_{82}\, z_7\,)$$

$$z_{448} = m_F\,(z_{84}\, z_{16} - z_{85}\, z_{15}\,) + m_{MR}\,(z_{81}\, z_{16} - z_{82}\, z_{15}\,)$$

$$z_{449} = -m_F\,(z_7\, z_{95} - z_{15}\, z_{96} - z_{16}\, z_{97}\,) - m_{MR}\,(z_7\, z_{92} - z_{15}\, z_{93} - z_{16}\, z_{94}\,)$$

$$z_{450} = I_{11}^F + I_{11}^{MR} + m_F\,(z_{84}^2 + z_{85}^2) + m_{MR}\,(z_{81}^2 + z_{82}^2)$$

$$z_{451} = -m_F\, z_{83}\, z_{85} - m_{MR}\, z_{80}\, z_{82}$$

$$z_{452} = -m_F\, z_{83}\, z_{84} - m_{MR}\, z_{80}\, z_{81}$$

$$z_{453} = z_{395} + z_{403} + m_F\,(z_{84}\, z_{97} - z_{85}\, z_{96}\,) + m_{MR}\,(z_{81}\, z_{94} - z_{82}\, z_{93}\,) - z_{399}$$

$$z_{454} = I_{22}^F + I_{22}^{MR} + m_F\,(z_{83}^2 + z_{85}^2) + m_{MR}\,(z_{80}^2 + z_{82}^2)$$

$$z_{455} = -m_F\, z_{84}\, z_{85} - m_{MR}\, z_{81}\, z_{82}$$

$$z_{456} = z_{394} + z_{400} + z_{402} - m_F\,(z_{83}\, z_{97} - z_{85}\, z_{95}\,) - m_{MR}\,(z_{80}\, z_{94} - z_{82}\, z_{92}\,)$$

$$z_{457} = I_{33}^F + I_{33}^{MR} + m_F\,(z_{83}^2 + z_{84}^2) + m_{MR}\,(z_{80}^2 + z_{81}^2)$$

$$z_{458} = z_{393} + z_{401} + m_F\,(z_{83}\, z_{96} - z_{84}\, z_{95}\,) + m_{MR}\,(z_{80}\, z_{93} - z_{81}\, z_{92}\,)$$

$$z_{459} = m_F\,(z_{83}\,z_{26} - z_{84}\,z_{21}) + m_{MR}\,(z_{80}\,z_{26} - z_{81}\,z_{21})$$

$$z_{460} = z_{76}\,(z_{21}\,z_{23} - z_{26}\,z_{31} - z_{27}\,z_{32})$$

$$z_{461} = -m_F\,(z_{83}\,z_{27} - z_{85}\,z_{21}) - m_{MR}\,(z_{80}\,z_{27} - z_{82}\,z_{21})$$

$$z_{462} = z_{76}\,(z_{21}^2 + z_{26}^2 + z_{27}^2)$$

$$z_{463} = z_{76}\,(z_{21}\,z_{28} + z_{26}\,z_{29} + z_{27}\,z_{30})$$

$$z_{464} = m_F\,(z_{84}\,z_{27} - z_{85}\,z_{26}) + m_{MR}\,(z_{81}\,z_{27} - z_{82}\,z_{26})$$

$$z_{465} = m_F\,(z_{21}\,z_{107} + z_{26}\,z_{108} + z_{27}\,z_{109}) + m_{MR}\,(z_{21}\,z_{104} + z_{26}\,z_{105} + z_{27}\,z_{106})$$

$$z_{466} = m_F\,(z_{83}\,z_{29} - z_{84}\,z_{28}) + m_{MR}\,(z_{80}\,z_{29} - z_{81}\,z_{28})$$

$$z_{467} = z_{76}\,(z_{23}\,z_{28} - z_{29}\,z_{31} - z_{30}\,z_{32})$$

$$z_{468} = -m_F\,(z_{83}\,z_{30} - z_{85}\,z_{28}) - m_{MR}\,(z_{80}\,z_{30} - z_{82}\,z_{28})$$

$$z_{469} = z_{76}\,(z_{28}^2 + z_{29}^2 + z_{30}^2)$$

$$z_{470} = m_F\,(z_{84}\,z_{30} - z_{85}\,z_{29}) + m_{MR}\,(z_{81}\,z_{30} - z_{82}\,z_{29})$$

$$z_{471} = m_F\,(z_{28}\,z_{107} + z_{29}\,z_{108} + z_{30}\,z_{109}) + m_{MR}\,(z_{28}\,z_{104} + z_{29}\,z_{105} + z_{30}\,z_{106})$$

$$z_{472} = m_F\,(z_{83}\,z_{31} + z_{84}\,z_{23}) + m_{MR}\,(z_{80}\,z_{31} + z_{81}\,z_{23})$$

$$z_{473} = z_{76}\,(z_{23}^2 + z_{31}^2 + z_{32}^2)$$

$$z_{474} = -m_F\,(z_{83}\,z_{32} + z_{85}\,z_{23}) - m_{MR}\,(z_{80}\,z_{32} + z_{82}\,z_{23})$$

$$z_{475} = m_F\,(z_{84}\,z_{32} - z_{85}\,z_{31}) + m_{MR}\,(z_{81}\,z_{32} - z_{82}\,z_{31})$$

$$z_{476} = -m_F\,(z_{23}\,z_{107} - z_{31}\,z_{108} - z_{32}\,z_{109}) - m_{MR}\,(z_{23}\,z_{104} - z_{31}\,z_{105} - z_{32}\,z_{106})$$

$$z_{477} = z_{409} + z_{417} + m_F\,(z_{84}\,z_{109} - z_{85}\,z_{108}) + m_{MR}\,(z_{81}\,z_{106} - z_{82}\,z_{105}) - z_{413}$$

$$z_{478} = z_{408} + z_{414} + z_{416} - m_F\,(z_{83}\,z_{109} - z_{85}\,z_{107}) - m_{MR}\,(z_{80}\,z_{106} - z_{82}\,z_{104})$$

$$z_{479} = z_{407} + z_{415} + m_F\,(z_{83}\,z_{108} - z_{84}\,z_{107}) + m_{MR}\,(z_{80}\,z_{105} - z_{81}\,z_{104})$$

$$z_{480} = m_F\,(z_{83}\,z_{42} - z_{84}\,z_{37}) + m_{MR}\,(z_{80}\,z_{42} - z_{81}\,z_{37})$$

$$z_{481} = z_{76}\,(z_{37}\,z_{39} - z_{42}\,z_{47} - z_{43}\,z_{48})$$

$$z_{482} = -m_F\,(z_{83}\,z_{43} - z_{85}\,z_{37}) - m_{MR}\,(z_{80}\,z_{43} - z_{82}\,z_{37})$$

$$z_{483} = z_{76}\,(z_{37}^2 + z_{42}^2 + z_{43}^2)$$

$$z_{484} = z_{76}\,(z_{37}\,z_{44} + z_{42}\,z_{45} + z_{43}\,z_{46})$$

$$z_{485} = m_F\,(z_{84}\,z_{43} - z_{85}\,z_{42}) + m_{MR}\,(z_{81}\,z_{43} - z_{82}\,z_{42})$$

$$z_{486} = m_F\,(z_{37}\,z_{119} + z_{42}\,z_{120} + z_{43}\,z_{121}) + m_{MR}\,(z_{37}\,z_{116} + z_{42}\,z_{117} + z_{43}\,z_{118})$$

$$z_{487} = m_F\,(z_{83}\,z_{45} - z_{84}\,z_{44}) + m_{MR}\,(z_{80}\,z_{45} - z_{81}\,z_{44})$$

$$z_{488} = z_{76}\,(z_{39}\,z_{44} - z_{45}\,z_{47} - z_{46}\,z_{48})$$

$$z_{489} = -m_F\,(z_{83}\,z_{46} - z_{85}\,z_{44}) - m_{MR}\,(z_{80}\,z_{46} - z_{82}\,z_{44})$$

$$z_{490} = z_{76}\,(z_{44}^2 + z_{45}^2 + z_{46}^2)$$

$$z_{491} = m_F\,(z_{84}\,z_{46} - z_{85}\,z_{45}) + m_{MR}\,(z_{81}\,z_{46} - z_{82}\,z_{45})$$

$$z_{492} = m_F\,(z_{44}\,z_{119} + z_{45}\,z_{120} + z_{46}\,z_{121}) + m_{MR}\,(z_{44}\,z_{116} + z_{45}\,z_{117} + z_{46}\,z_{118})$$

$$z_{493} = m_F\,(z_{83}\,z_{47} + z_{84}\,z_{39}) + m_{MR}\,(z_{80}\,z_{47} + z_{81}\,z_{39})$$

$$z_{494} = z_{76}\,(z_{39}^2 + z_{47}^2 + z_{48}^2)$$

$$z_{495} = -m_F\,(z_{83}\,z_{48} + z_{85}\,z_{39}) - m_{MR}\,(z_{80}\,z_{48} + z_{82}\,z_{39})$$

$$z_{496} = m_F\,(z_{84}\,z_{48} - z_{85}\,z_{47}) + m_{MR}\,(z_{81}\,z_{48} - z_{82}\,z_{47})$$

$$z_{497} = -m_F\,(z_{39}\,z_{119} - z_{47}\,z_{120} - z_{48}\,z_{121}) - m_{MR}\,(z_{39}\,z_{116} - z_{47}\,z_{117} - z_{48}\,z_{118})$$

$$z_{498} = z_{423} + z_{431} + m_F\,(z_{84}\,z_{121} - z_{85}\,z_{120}) + m_{MR}\,(z_{81}\,z_{118} - z_{82}\,z_{117}) - z_{427}$$

$$z_{499} = z_{422} + z_{428} + z_{430} - m_F\,(z_{83}\,z_{121} - z_{85}\,z_{119}) - m_{MR}\,(z_{80}\,z_{118} - z_{82}\,z_{116})$$

$$z_{500} = z_{421} + z_{429} + m_F\,(z_{83}\,z_{120} - z_{84}\,z_{119}) + m_{MR}\,(z_{80}\,z_{117} - z_{81}\,z_{116})$$

$$z_{501} = l_{\prime p}\,z_{210}$$

$$z_{502} = l_{\prime p}\,z_{228}$$

$$z_{503} = l_{\prime p}\,z_{246}$$

$$z_{504} = z_{435} + z_{210}\,z_{501} + z_{228}\,z_{502} + z_{246}\,z_{503}$$

$$z_{505} = z_{436} + z_{211}\,z_{501} + z_{229}\,z_{502} + z_{247}\,z_{503}$$

$$z_{506} = z_{212}\,z_{501} + z_{230}\,z_{502} + z_{248}\,z_{503} - z_{433}$$

$$z_{507} = z_{437} + z_{215}\,z_{501} + z_{233}\,z_{502} + z_{251}\,z_{503}$$

$$z_{508} = z_{434} + z_{214}\,z_{501} + z_{232}\,z_{502} + z_{250}\,z_{503}$$

$$z_{509} = z_{432} + z_{213}\,z_{501} + z_{231}\,z_{502} + z_{249}\,z_{503}$$

$$z_{510} = -z_{220}\,z_{501} - z_{238}\,z_{502} - z_{256}\,z_{503}$$

$$z_{511} = -z_{221}\,z_{501} - z_{239}\,z_{502} - z_{257}\,z_{503}$$

$$z_{512} = -z_{216}\,z_{501} - z_{234}\,z_{502} - z_{252}\,z_{503}$$

$$z_{513} = -z_{219}\,z_{501} - z_{237}\,z_{502} - z_{255}\,z_{503}$$

$$z_{514} = -z_{218}\,z_{501} - z_{236}\,z_{502} - z_{254}\,z_{503}$$

$$z_{515} = -z_{217}\,z_{501} - z_{235}\,z_{502} - z_{253}\,z_{503}$$

$$z_{516} = z_{222}\,z_{501} + z_{240}\,z_{502} + z_{258}\,z_{503}$$

$$z_{517} = z_{223}\, z_{501} + z_{241}\, z_{502} + z_{259}\, z_{503}$$

$$z_{518} = z_{224}\, z_{501} + z_{242}\, z_{502} + z_{260}\, z_{503}$$

$$z_{519} = z_{227}\, z_{501} + z_{245}\, z_{502} + z_{263}\, z_{503}$$

$$z_{520} = z_{226}\, z_{501} + z_{244}\, z_{502} + z_{262}\, z_{503}$$

$$z_{521} = z_{225}\, z_{501} + z_{243}\, z_{502} + z_{261}\, z_{503}$$

$$z_{522} = z_{438} + z_{501}\, z_{366} + z_{502}\, z_{367} + z_{503}\, z_{368}$$

$$z_{523} = l_{\mathit{rp}}\, z_{211}$$

$$z_{524} = l_{\mathit{rp}}\, z_{229}$$

$$z_{525} = l_{\mathit{rp}}\, z_{247}$$

$$z_{526} = z_{436} + z_{210}\, z_{523} + z_{228}\, z_{524} + z_{246}\, z_{525}$$

$$z_{527} = z_{442} + z_{211}\, z_{523} + z_{229}\, z_{524} + z_{247}\, z_{525}$$

$$z_{528} = z_{212}\, z_{523} + z_{230}\, z_{524} + z_{248}\, z_{525} - z_{440}$$

$$z_{529} = z_{443} + z_{215}\, z_{523} + z_{233}\, z_{524} + z_{251}\, z_{525}$$

$$z_{530} = z_{441} + z_{214}\, z_{523} + z_{232}\, z_{524} + z_{250}\, z_{525}$$

$$z_{531} = z_{439} + z_{213}\, z_{523} + z_{231}\, z_{524} + z_{249}\, z_{525}$$

$$z_{532} = -z_{220}\, z_{523} - z_{238}\, z_{524} - z_{256}\, z_{525}$$

$$z_{533} = -z_{221}\, z_{523} - z_{239}\, z_{524} - z_{257}\, z_{525}$$

$$z_{534} = -z_{216}\, z_{523} - z_{234}\, z_{524} - z_{252}\, z_{525}$$

$$z_{535} = -z_{219}\, z_{523} - z_{237}\, z_{524} - z_{255}\, z_{525}$$

$$z_{536} = -z_{218}\, z_{523} - z_{236}\, z_{524} - z_{254}\, z_{525}$$

$$z_{537} = -z_{217}\, z_{523} - z_{235}\, z_{524} - z_{253}\, z_{525}$$

$$z_{538} = z_{222}\, z_{523} + z_{240}\, z_{524} + z_{258}\, z_{525}$$

$$z_{539} = z_{223}\, z_{523} + z_{241}\, z_{524} + z_{259}\, z_{525}$$

$$z_{540} = z_{224}\, z_{523} + z_{242}\, z_{524} + z_{260}\, z_{525}$$

$$z_{541} = z_{227}\, z_{523} + z_{245}\, z_{524} + z_{263}\, z_{525}$$

$$z_{542} = z_{226}\, z_{523} + z_{244}\, z_{524} + z_{262}\, z_{525}$$

$$z_{543} = z_{225}\, z_{523} + z_{243}\, z_{524} + z_{261}\, z_{525}$$

$$z_{544} = z_{444} + z_{523}\, z_{366} + z_{524}\, z_{367} + z_{525}\, z_{368}$$

$$z_{545} = l_{\mathit{rp}}\, z_{212}$$

$$z_{546} = l_{\mathit{rp}}\, z_{230}$$

$$z_{547} = l_{\mathit{rp}}\, z_{248}$$

$$z_{548} = z_{210}\, z_{545} + z_{228}\, z_{546} + z_{246}\, z_{547} - z_{433}$$

$$z_{549} = z_{211}\, z_{545} + z_{229}\, z_{546} + z_{247}\, z_{547} - z_{440}$$
$$z_{550} = z_{446} + z_{212}\, z_{545} + z_{230}\, z_{546} + z_{248}\, z_{547}$$
$$z_{551} = z_{448} + z_{215}\, z_{545} + z_{233}\, z_{546} + z_{251}\, z_{547}$$
$$z_{552} = z_{447} + z_{214}\, z_{545} + z_{232}\, z_{546} + z_{250}\, z_{547}$$
$$z_{553} = z_{445} + z_{213}\, z_{545} + z_{231}\, z_{546} + z_{249}\, z_{547}$$
$$z_{554} = -z_{220}\, z_{545} - z_{238}\, z_{546} - z_{256}\, z_{547}$$
$$z_{555} = -z_{221}\, z_{545} - z_{239}\, z_{546} - z_{257}\, z_{547}$$
$$z_{556} = -z_{216}\, z_{545} - z_{234}\, z_{546} - z_{252}\, z_{547}$$
$$z_{557} = -z_{219}\, z_{545} - z_{237}\, z_{546} - z_{255}\, z_{547}$$
$$z_{558} = -z_{218}\, z_{545} - z_{236}\, z_{546} - z_{254}\, z_{547}$$
$$z_{559} = -z_{217}\, z_{545} - z_{235}\, z_{546} - z_{253}\, z_{547}$$
$$z_{560} = z_{222}\, z_{545} + z_{240}\, z_{546} + z_{258}\, z_{547}$$
$$z_{561} = z_{223}\, z_{545} + z_{241}\, z_{546} + z_{259}\, z_{547}$$
$$z_{562} = z_{224}\, z_{545} + z_{242}\, z_{546} + z_{260}\, z_{547}$$
$$z_{563} = z_{227}\, z_{545} + z_{245}\, z_{546} + z_{263}\, z_{547}$$
$$z_{564} = z_{226}\, z_{545} + z_{244}\, z_{546} + z_{262}\, z_{547}$$
$$z_{565} = z_{225}\, z_{545} + z_{243}\, z_{546} + z_{261}\, z_{547}$$
$$z_{566} = z_{449} + z_{545}\, z_{366} + z_{546}\, z_{367} + z_{547}\, z_{368}$$
$$z_{567} = l_{\eta p}\, z_{215}$$
$$z_{568} = l_{\eta p}\, z_{233}$$
$$z_{569} = l_{\eta p}\, z_{251}$$
$$z_{570} = z_{437} + z_{210}\, z_{567} + z_{228}\, z_{568} + z_{246}\, z_{569}$$
$$z_{571} = z_{443} + z_{211}\, z_{567} + z_{229}\, z_{568} + z_{247}\, z_{569}$$
$$z_{572} = z_{448} + z_{212}\, z_{567} + z_{230}\, z_{568} + z_{248}\, z_{569}$$
$$z_{573} = z_{450} + z_{215}\, z_{567} + z_{233}\, z_{568} + z_{251}\, z_{569}$$
$$z_{574} = z_{452} + z_{214}\, z_{567} + z_{232}\, z_{568} + z_{250}\, z_{569}$$
$$z_{575} = z_{451} + z_{213}\, z_{567} + z_{231}\, z_{568} + z_{249}\, z_{569}$$
$$z_{576} = -z_{220}\, z_{567} - z_{238}\, z_{568} - z_{256}\, z_{569}$$
$$z_{577} = -z_{221}\, z_{567} - z_{239}\, z_{568} - z_{257}\, z_{569}$$
$$z_{578} = -z_{216}\, z_{567} - z_{234}\, z_{568} - z_{252}\, z_{569}$$
$$z_{579} = -z_{219}\, z_{567} - z_{237}\, z_{568} - z_{255}\, z_{569}$$
$$z_{580} = -z_{218}\, z_{567} - z_{236}\, z_{568} - z_{254}\, z_{569}$$
$$z_{581} = -z_{217}\, z_{567} - z_{235}\, z_{568} - z_{253}\, z_{569}$$

$$z_{582} = z_{222}\, z_{567} + z_{240}\, z_{568} + z_{258}\, z_{569}$$

$$z_{583} = z_{223}\, z_{567} + z_{241}\, z_{568} + z_{259}\, z_{569}$$

$$z_{584} = z_{224}\, z_{567} + z_{242}\, z_{568} + z_{260}\, z_{569}$$

$$z_{585} = z_{227}\, z_{567} + z_{245}\, z_{568} + z_{263}\, z_{569}$$

$$z_{586} = z_{226}\, z_{567} + z_{244}\, z_{568} + z_{262}\, z_{569}$$

$$z_{587} = z_{225}\, z_{567} + z_{243}\, z_{568} + z_{261}\, z_{569}$$

$$z_{588} = z_{453} + z_{567}\, z_{366} + z_{568}\, z_{367} + z_{569}\, z_{368}$$

$$z_{589} = l_{\eta p}\, z_{214}$$

$$z_{590} = l_{\eta p}\, z_{232}$$

$$z_{591} = l_{\eta p}\, z_{250}$$

$$z_{592} = z_{434} + z_{210}\, z_{589} + z_{228}\, z_{590} + z_{246}\, z_{591}$$

$$z_{593} = z_{441} + z_{211}\, z_{589} + z_{229}\, z_{590} + z_{247}\, z_{591}$$

$$z_{594} = z_{447} + z_{212}\, z_{589} + z_{230}\, z_{590} + z_{248}\, z_{591}$$

$$z_{595} = z_{452} + z_{215}\, z_{589} + z_{233}\, z_{590} + z_{251}\, z_{591}$$

$$z_{596} = z_{454} + z_{214}\, z_{589} + z_{232}\, z_{590} + z_{250}\, z_{591}$$

$$z_{597} = z_{455} + z_{213}\, z_{589} + z_{231}\, z_{590} + z_{249}\, z_{591}$$

$$z_{598} = -z_{220}\, z_{589} - z_{238}\, z_{590} - z_{256}\, z_{591}$$

$$z_{599} = -z_{221}\, z_{589} - z_{239}\, z_{590} - z_{257}\, z_{591}$$

$$z_{600} = -z_{216}\, z_{589} - z_{234}\, z_{590} - z_{252}\, z_{591}$$

$$z_{601} = -z_{219}\, z_{589} - z_{237}\, z_{590} - z_{255}\, z_{591}$$

$$z_{602} = -z_{218}\, z_{589} - z_{236}\, z_{590} - z_{254}\, z_{591}$$

$$z_{603} = -z_{217}\, z_{589} - z_{235}\, z_{590} - z_{253}\, z_{591}$$

$$z_{604} = z_{222}\, z_{589} + z_{240}\, z_{590} + z_{258}\, z_{591}$$

$$z_{605} = z_{223}\, z_{589} + z_{241}\, z_{590} + z_{259}\, z_{591}$$

$$z_{606} = z_{224}\, z_{589} + z_{242}\, z_{590} + z_{260}\, z_{591}$$

$$z_{607} = z_{227}\, z_{589} + z_{245}\, z_{590} + z_{263}\, z_{591}$$

$$z_{608} = z_{226}\, z_{589} + z_{244}\, z_{590} + z_{262}\, z_{591}$$

$$z_{609} = z_{225}\, z_{589} + z_{243}\, z_{590} + z_{261}\, z_{591}$$

$$z_{610} = z_{456} + z_{589}\, z_{366} + z_{590}\, z_{367} + z_{591}\, z_{368}$$

$$z_{611} = l_{\eta p}\, z_{213}$$

$$z_{612} = l_{\eta p}\, z_{231}$$

$$z_{613} = l_{\eta p}\, z_{249}$$

$$z_{614} = z_{432} + z_{210}\, z_{611} + z_{228}\, z_{612} + z_{246}\, z_{613}$$
$$z_{615} = z_{439} + z_{211}\, z_{611} + z_{229}\, z_{612} + z_{247}\, z_{613}$$
$$z_{616} = z_{445} + z_{212}\, z_{611} + z_{230}\, z_{612} + z_{248}\, z_{613}$$
$$z_{617} = z_{451} + z_{215}\, z_{611} + z_{233}\, z_{612} + z_{251}\, z_{613}$$
$$z_{618} = z_{455} + z_{214}\, z_{611} + z_{232}\, z_{612} + z_{250}\, z_{613}$$
$$z_{619} = z_{457} + z_{213}\, z_{611} + z_{231}\, z_{612} + z_{249}\, z_{613}$$
$$z_{620} = -z_{220}\, z_{611} - z_{238}\, z_{612} - z_{256}\, z_{613}$$
$$z_{621} = -z_{221}\, z_{611} - z_{239}\, z_{612} - z_{257}\, z_{613}$$
$$z_{622} = -z_{216}\, z_{611} - z_{234}\, z_{612} - z_{252}\, z_{613}$$
$$z_{623} = -z_{219}\, z_{611} - z_{237}\, z_{612} - z_{255}\, z_{613}$$
$$z_{624} = -z_{218}\, z_{611} - z_{236}\, z_{612} - z_{254}\, z_{613}$$
$$z_{625} = -z_{217}\, z_{611} - z_{235}\, z_{612} - z_{253}\, z_{613}$$
$$z_{626} = z_{222}\, z_{611} + z_{240}\, z_{612} + z_{258}\, z_{613}$$
$$z_{627} = z_{223}\, z_{611} + z_{241}\, z_{612} + z_{259}\, z_{613}$$
$$z_{628} = z_{224}\, z_{611} + z_{242}\, z_{612} + z_{260}\, z_{613}$$
$$z_{629} = z_{227}\, z_{611} + z_{245}\, z_{612} + z_{263}\, z_{613}$$
$$z_{630} = z_{226}\, z_{611} + z_{244}\, z_{612} + z_{262}\, z_{613}$$
$$z_{631} = z_{225}\, z_{611} + z_{243}\, z_{612} + z_{261}\, z_{613}$$
$$z_{632} = z_{458} + z_{611}\, z_{366} + z_{612}\, z_{367} + z_{613}\, z_{368}$$
$$z_{633} = l_{\prime p}\, z_{220}$$
$$z_{634} = l_{\prime p}\, z_{238}$$
$$z_{635} = l_{\prime p}\, z_{256}$$
$$z_{636} = -z_{210}\, z_{633} - z_{228}\, z_{634} - z_{246}\, z_{635}$$
$$z_{637} = -z_{211}\, z_{633} - z_{229}\, z_{634} - z_{247}\, z_{635}$$
$$z_{638} = -z_{212}\, z_{633} - z_{230}\, z_{634} - z_{248}\, z_{635}$$
$$z_{639} = -z_{215}\, z_{633} - z_{233}\, z_{634} - z_{251}\, z_{635}$$
$$z_{640} = -z_{214}\, z_{633} - z_{232}\, z_{634} - z_{250}\, z_{635}$$
$$z_{641} = -z_{213}\, z_{633} - z_{231}\, z_{634} - z_{249}\, z_{635}$$
$$z_{642} = z_{462} + z_{220}\, z_{633} + z_{238}\, z_{634} + z_{256}\, z_{635}$$
$$z_{643} = z_{463} + z_{221}\, z_{633} + z_{239}\, z_{634} + z_{257}\, z_{635}$$
$$z_{644} = z_{216}\, z_{633} + z_{234}\, z_{634} + z_{252}\, z_{635} - z_{460}$$
$$z_{645} = z_{464} + z_{219}\, z_{633} + z_{237}\, z_{634} + z_{255}\, z_{635}$$
$$z_{646} = z_{461} + z_{218}\, z_{633} + z_{236}\, z_{634} + z_{254}\, z_{635}$$

$$z_{647} = z_{459} + z_{217}\, z_{633} + z_{235}\, z_{634} + z_{253}\, z_{635}$$

$$z_{648} = -z_{222}\, z_{633} - z_{240}\, z_{634} - z_{258}\, z_{635}$$

$$z_{649} = -z_{223}\, z_{633} - z_{241}\, z_{634} - z_{259}\, z_{635}$$

$$z_{650} = -z_{224}\, z_{633} - z_{242}\, z_{634} - z_{260}\, z_{635}$$

$$z_{651} = -z_{227}\, z_{633} - z_{245}\, z_{634} - z_{263}\, z_{635}$$

$$z_{652} = -z_{226}\, z_{633} - z_{244}\, z_{634} - z_{262}\, z_{635}$$

$$z_{653} = -z_{225}\, z_{633} - z_{243}\, z_{634} - z_{261}\, z_{635}$$

$$z_{654} = z_{465} - z_{633}\, z_{366} - z_{634}\, z_{367} - z_{635}\, z_{368}$$

$$z_{655} = l_{\mathit{rp}}\, z_{221}$$

$$z_{656} = l_{\mathit{rp}}\, z_{239}$$

$$z_{657} = l_{\mathit{rp}}\, z_{257}$$

$$z_{658} = -z_{210}\, z_{655} - z_{228}\, z_{656} - z_{246}\, z_{657}$$

$$z_{659} = -z_{211}\, z_{655} - z_{229}\, z_{656} - z_{247}\, z_{657}$$

$$z_{660} = -z_{212}\, z_{655} - z_{230}\, z_{656} - z_{248}\, z_{657}$$

$$z_{661} = -z_{215}\, z_{655} - z_{233}\, z_{656} - z_{251}\, z_{657}$$

$$z_{662} = -z_{214}\, z_{655} - z_{232}\, z_{656} - z_{250}\, z_{657}$$

$$z_{663} = -z_{213}\, z_{655} - z_{231}\, z_{656} - z_{249}\, z_{657}$$

$$z_{664} = z_{463} + z_{220}\, z_{655} + z_{238}\, z_{656} + z_{256}\, z_{657}$$

$$z_{665} = z_{469} + z_{221}\, z_{655} + z_{239}\, z_{656} + z_{257}\, z_{657}$$

$$z_{666} = z_{216}\, z_{655} + z_{234}\, z_{656} + z_{252}\, z_{657} - z_{467}$$

$$z_{667} = z_{470} + z_{219}\, z_{655} + z_{237}\, z_{656} + z_{255}\, z_{657}$$

$$z_{668} = z_{468} + z_{218}\, z_{655} + z_{236}\, z_{656} + z_{254}\, z_{657}$$

$$z_{669} = z_{466} + z_{217}\, z_{655} + z_{235}\, z_{656} + z_{253}\, z_{657}$$

$$z_{670} = -z_{222}\, z_{655} - z_{240}\, z_{656} - z_{258}\, z_{657}$$

$$z_{671} = -z_{223}\, z_{655} - z_{241}\, z_{656} - z_{259}\, z_{657}$$

$$z_{672} = -z_{224}\, z_{655} - z_{242}\, z_{656} - z_{260}\, z_{657}$$

$$z_{673} = -z_{227}\, z_{655} - z_{245}\, z_{656} - z_{263}\, z_{657}$$

$$z_{674} = -z_{226}\, z_{655} - z_{244}\, z_{656} - z_{262}\, z_{657}$$

$$z_{675} = -z_{225}\, z_{655} - z_{243}\, z_{656} - z_{261}\, z_{657}$$

$$z_{676} = z_{471} - z_{655}\, z_{366} - z_{656}\, z_{367} - z_{657}\, z_{368}$$

$$z_{677} = l_{\mathit{rp}}\, z_{216}$$

$$z_{678} = l_{\mathit{rp}}\, z_{234}$$

$$z_{679} = l_{rp}\, z_{252}$$

$$z_{680} = -z_{210}\, z_{677} - z_{228}\, z_{678} - z_{246}\, z_{679}$$

$$z_{681} = -z_{211}\, z_{677} - z_{229}\, z_{678} - z_{247}\, z_{679}$$

$$z_{682} = -z_{212}\, z_{677} - z_{230}\, z_{678} - z_{248}\, z_{679}$$

$$z_{683} = -z_{215}\, z_{677} - z_{233}\, z_{678} - z_{251}\, z_{679}$$

$$z_{684} = -z_{214}\, z_{677} - z_{232}\, z_{678} - z_{250}\, z_{679}$$

$$z_{685} = -z_{213}\, z_{677} - z_{231}\, z_{678} - z_{249}\, z_{679}$$

$$z_{686} = z_{220}\, z_{677} + z_{238}\, z_{678} + z_{256}\, z_{679} - z_{460}$$

$$z_{687} = z_{221}\, z_{677} + z_{239}\, z_{678} + z_{257}\, z_{679} - z_{467}$$

$$z_{688} = z_{473} + z_{216}\, z_{677} + z_{234}\, z_{678} + z_{252}\, z_{679}$$

$$z_{689} = z_{475} + z_{219}\, z_{677} + z_{237}\, z_{678} + z_{255}\, z_{679}$$

$$z_{690} = z_{474} + z_{218}\, z_{677} + z_{236}\, z_{678} + z_{254}\, z_{679}$$

$$z_{691} = z_{472} + z_{217}\, z_{677} + z_{235}\, z_{678} + z_{253}\, z_{679}$$

$$z_{692} = -z_{222}\, z_{677} - z_{240}\, z_{678} - z_{258}\, z_{679}$$

$$z_{693} = -z_{223}\, z_{677} - z_{241}\, z_{678} - z_{259}\, z_{679}$$

$$z_{694} = -z_{224}\, z_{677} - z_{242}\, z_{678} - z_{260}\, z_{679}$$

$$z_{695} = -z_{227}\, z_{677} - z_{245}\, z_{678} - z_{263}\, z_{679}$$

$$z_{696} = -z_{226}\, z_{677} - z_{244}\, z_{678} - z_{262}\, z_{679}$$

$$z_{697} = -z_{225}\, z_{677} - z_{243}\, z_{678} - z_{261}\, z_{679}$$

$$z_{698} = z_{476} - z_{677}\, z_{366} - z_{678}\, z_{367} - z_{679}\, z_{368}$$

$$z_{699} = l_{rp}\, z_{219}$$

$$z_{700} = l_{rp}\, z_{237}$$

$$z_{701} = l_{rp}\, z_{255}$$

$$z_{702} = -z_{210}\, z_{699} - z_{228}\, z_{700} - z_{246}\, z_{701}$$

$$z_{703} = -z_{211}\, z_{699} - z_{229}\, z_{700} - z_{247}\, z_{701}$$

$$z_{704} = -z_{212}\, z_{699} - z_{230}\, z_{700} - z_{248}\, z_{701}$$

$$z_{705} = -z_{215}\, z_{699} - z_{233}\, z_{700} - z_{251}\, z_{701}$$

$$z_{706} = -z_{214}\, z_{699} - z_{232}\, z_{700} - z_{250}\, z_{701}$$

$$z_{707} = -z_{213}\, z_{699} - z_{231}\, z_{700} - z_{249}\, z_{701}$$

$$z_{708} = z_{464} + z_{220}\, z_{699} + z_{238}\, z_{700} + z_{256}\, z_{701}$$

$$z_{709} = z_{470} + z_{221}\, z_{699} + z_{239}\, z_{700} + z_{257}\, z_{701}$$

$$z_{710} = z_{475} + z_{216}\, z_{699} + z_{234}\, z_{700} + z_{252}\, z_{701}$$

$$z_{711} = z_{450} + z_{219}\, z_{699} + z_{237}\, z_{700} + z_{255}\, z_{701}$$

$$z_{712} = z_{452} + z_{218}\, z_{699} + z_{236}\, z_{700} + z_{254}\, z_{701}$$

$$z_{713} = z_{451} + z_{217}\, z_{699} + z_{235}\, z_{700} + z_{253}\, z_{701}$$

$$z_{714} = -z_{222}\, z_{699} - z_{240}\, z_{700} - z_{258}\, z_{701}$$

$$z_{715} = -z_{223}\, z_{699} - z_{241}\, z_{700} - z_{259}\, z_{701}$$

$$z_{716} = -z_{224}\, z_{699} - z_{242}\, z_{700} - z_{260}\, z_{701}$$

$$z_{717} = -z_{227}\, z_{699} - z_{245}\, z_{700} - z_{263}\, z_{701}$$

$$z_{718} = -z_{226}\, z_{699} - z_{244}\, z_{700} - z_{262}\, z_{701}$$

$$z_{719} = -z_{225}\, z_{699} - z_{243}\, z_{700} - z_{261}\, z_{701}$$

$$z_{720} = z_{477} - z_{699}\, z_{366} - z_{700}\, z_{367} - z_{701}\, z_{368}$$

$$z_{721} = l_{rp}\, z_{218}$$

$$z_{722} = l_{rp}\, z_{236}$$

$$z_{723} = l_{rp}\, z_{254}$$

$$z_{724} = -z_{210}\, z_{721} - z_{228}\, z_{722} - z_{246}\, z_{723}$$

$$z_{725} = -z_{211}\, z_{721} - z_{229}\, z_{722} - z_{247}\, z_{723}$$

$$z_{726} = -z_{212}\, z_{721} - z_{230}\, z_{722} - z_{248}\, z_{723}$$

$$z_{727} = -z_{215}\, z_{721} - z_{233}\, z_{722} - z_{251}\, z_{723}$$

$$z_{728} = -z_{214}\, z_{721} - z_{232}\, z_{722} - z_{250}\, z_{723}$$

$$z_{729} = -z_{213}\, z_{721} - z_{231}\, z_{722} - z_{249}\, z_{723}$$

$$z_{730} = z_{461} + z_{220}\, z_{721} + z_{238}\, z_{722} + z_{256}\, z_{723}$$

$$z_{731} = z_{468} + z_{221}\, z_{721} + z_{239}\, z_{722} + z_{257}\, z_{723}$$

$$z_{732} = z_{474} + z_{216}\, z_{721} + z_{234}\, z_{722} + z_{252}\, z_{723}$$

$$z_{733} = z_{452} + z_{219}\, z_{721} + z_{237}\, z_{722} + z_{255}\, z_{723}$$

$$z_{734} = z_{454} + z_{218}\, z_{721} + z_{236}\, z_{722} + z_{254}\, z_{723}$$

$$z_{735} = z_{455} + z_{217}\, z_{721} + z_{235}\, z_{722} + z_{253}\, z_{723}$$

$$z_{736} = -z_{222}\, z_{721} - z_{240}\, z_{722} - z_{258}\, z_{723}$$

$$z_{737} = -z_{223}\, z_{721} - z_{241}\, z_{722} - z_{259}\, z_{723}$$

$$z_{738} = -z_{224}\, z_{721} - z_{242}\, z_{722} - z_{260}\, z_{723}$$

$$z_{739} = -z_{227}\, z_{721} - z_{245}\, z_{722} - z_{263}\, z_{723}$$

$$z_{740} = -z_{226}\, z_{721} - z_{244}\, z_{722} - z_{262}\, z_{723}$$

$$z_{741} = -z_{225}\, z_{721} - z_{243}\, z_{722} - z_{261}\, z_{723}$$

$$z_{742} = z_{478} - z_{721}\, z_{366} - z_{722}\, z_{367} - z_{723}\, z_{368}$$

$$z_{743} = l_{\mathit{rp}}\, z_{217}$$

$$z_{744} = l_{\mathit{rp}}\, z_{235}$$

$$z_{745} = l_{\mathit{rp}}\, z_{253}$$

$$z_{746} = -z_{210}\, z_{743} - z_{228}\, z_{744} - z_{246}\, z_{745}$$

$$z_{747} = -z_{211}\, z_{743} - z_{229}\, z_{744} - z_{247}\, z_{745}$$

$$z_{748} = -z_{212}\, z_{743} - z_{230}\, z_{744} - z_{248}\, z_{745}$$

$$z_{749} = -z_{215}\, z_{743} - z_{233}\, z_{744} - z_{251}\, z_{745}$$

$$z_{750} = -z_{214}\, z_{743} - z_{232}\, z_{744} - z_{250}\, z_{745}$$

$$z_{751} = -z_{213}\, z_{743} - z_{231}\, z_{744} - z_{249}\, z_{745}$$

$$z_{752} = z_{459} + z_{220}\, z_{743} + z_{238}\, z_{744} + z_{256}\, z_{745}$$

$$z_{753} = z_{466} + z_{221}\, z_{743} + z_{239}\, z_{744} + z_{257}\, z_{745}$$

$$z_{754} = z_{472} + z_{216}\, z_{743} + z_{234}\, z_{744} + z_{252}\, z_{745}$$

$$z_{755} = z_{451} + z_{219}\, z_{743} + z_{237}\, z_{744} + z_{255}\, z_{745}$$

$$z_{756} = z_{455} + z_{218}\, z_{743} + z_{236}\, z_{744} + z_{254}\, z_{745}$$

$$z_{757} = z_{457} + z_{217}\, z_{743} + z_{235}\, z_{744} + z_{253}\, z_{745}$$

$$z_{758} = -z_{222}\, z_{743} - z_{240}\, z_{744} - z_{258}\, z_{745}$$

$$z_{759} = -z_{223}\, z_{743} - z_{241}\, z_{744} - z_{259}\, z_{745}$$

$$z_{760} = -z_{224}\, z_{743} - z_{242}\, z_{744} - z_{260}\, z_{745}$$

$$z_{761} = -z_{227}\, z_{743} - z_{245}\, z_{744} - z_{263}\, z_{745}$$

$$z_{762} = -z_{226}\, z_{743} - z_{244}\, z_{744} - z_{262}\, z_{745}$$

$$z_{763} = -z_{225}\, z_{743} - z_{243}\, z_{744} - z_{261}\, z_{745}$$

$$z_{764} = z_{479} - z_{743}\, z_{366} - z_{744}\, z_{367} - z_{745}\, z_{368}$$

$$z_{765} = l_{\mathit{rp}}\, z_{222}$$

$$z_{766} = l_{\mathit{rp}}\, z_{240}$$

$$z_{767} = l_{\mathit{rp}}\, z_{258}$$

$$z_{768} = z_{210}\, z_{765} + z_{228}\, z_{766} + z_{246}\, z_{767}$$

$$z_{769} = z_{211}\, z_{765} + z_{229}\, z_{766} + z_{247}\, z_{767}$$

$$z_{770} = z_{212}\, z_{765} + z_{230}\, z_{766} + z_{248}\, z_{767}$$

$$z_{771} = z_{215}\, z_{765} + z_{233}\, z_{766} + z_{251}\, z_{767}$$

$$z_{772} = z_{214}\, z_{765} + z_{232}\, z_{766} + z_{250}\, z_{767}$$

$$z_{773} = z_{213}\, z_{765} + z_{231}\, z_{766} + z_{249}\, z_{767}$$

$$z_{774} = -z_{220}\, z_{765} - z_{238}\, z_{766} - z_{256}\, z_{767}$$

$$z_{775} = -z_{221}\, z_{765} - z_{239}\, z_{766} - z_{257}\, z_{767}$$
$$z_{776} = -z_{216}\, z_{765} - z_{234}\, z_{766} - z_{252}\, z_{767}$$
$$z_{777} = -z_{219}\, z_{765} - z_{237}\, z_{766} - z_{255}\, z_{767}$$
$$z_{778} = -z_{218}\, z_{765} - z_{236}\, z_{766} - z_{254}\, z_{767}$$
$$z_{779} = -z_{217}\, z_{765} - z_{235}\, z_{766} - z_{253}\, z_{767}$$
$$z_{780} = z_{483} + z_{222}\, z_{765} + z_{240}\, z_{766} + z_{258}\, z_{767}$$
$$z_{781} = z_{484} + z_{223}\, z_{765} + z_{241}\, z_{766} + z_{259}\, z_{767}$$
$$z_{782} = z_{224}\, z_{765} + z_{242}\, z_{766} + z_{260}\, z_{767} - z_{481}$$
$$z_{783} = z_{485} + z_{227}\, z_{765} + z_{245}\, z_{766} + z_{263}\, z_{767}$$
$$z_{784} = z_{482} + z_{226}\, z_{765} + z_{244}\, z_{766} + z_{262}\, z_{767}$$
$$z_{785} = z_{480} + z_{225}\, z_{765} + z_{243}\, z_{766} + z_{261}\, z_{767}$$
$$z_{786} = z_{486} + z_{765}\, z_{366} + z_{766}\, z_{367} + z_{767}\, z_{368}$$
$$z_{787} = l_{\mathit{rp}}\, z_{223}$$
$$z_{788} = l_{\mathit{rp}}\, z_{241}$$
$$z_{789} = l_{\mathit{rp}}\, z_{259}$$
$$z_{790} = z_{210}\, z_{787} + z_{228}\, z_{788} + z_{246}\, z_{789}$$
$$z_{791} = z_{211}\, z_{787} + z_{229}\, z_{788} + z_{247}\, z_{789}$$
$$z_{792} = z_{212}\, z_{787} + z_{230}\, z_{788} + z_{248}\, z_{789}$$
$$z_{793} = z_{215}\, z_{787} + z_{233}\, z_{788} + z_{251}\, z_{789}$$
$$z_{794} = z_{214}\, z_{787} + z_{232}\, z_{788} + z_{250}\, z_{789}$$
$$z_{795} = z_{213}\, z_{787} + z_{231}\, z_{788} + z_{249}\, z_{789}$$
$$z_{796} = -z_{220}\, z_{787} - z_{238}\, z_{788} - z_{256}\, z_{789}$$
$$z_{797} = -z_{221}\, z_{787} - z_{239}\, z_{788} - z_{257}\, z_{789}$$
$$z_{798} = -z_{216}\, z_{787} - z_{234}\, z_{788} - z_{252}\, z_{789}$$
$$z_{799} = -z_{219}\, z_{787} - z_{237}\, z_{788} - z_{255}\, z_{789}$$
$$z_{800} = -z_{218}\, z_{787} - z_{236}\, z_{788} - z_{254}\, z_{789}$$
$$z_{801} = -z_{217}\, z_{787} - z_{235}\, z_{788} - z_{253}\, z_{789}$$
$$z_{802} = z_{484} + z_{222}\, z_{787} + z_{240}\, z_{788} + z_{258}\, z_{789}$$
$$z_{803} = z_{490} + z_{223}\, z_{787} + z_{241}\, z_{788} + z_{259}\, z_{789}$$
$$z_{804} = z_{224}\, z_{787} + z_{242}\, z_{788} + z_{260}\, z_{789} - z_{488}$$
$$z_{805} = z_{491} + z_{227}\, z_{787} + z_{245}\, z_{788} + z_{263}\, z_{789}$$
$$z_{806} = z_{489} + z_{226}\, z_{787} + z_{244}\, z_{788} + z_{262}\, z_{789}$$
$$z_{807} = z_{487} + z_{225}\, z_{787} + z_{243}\, z_{788} + z_{261}\, z_{789}$$

$$z_{808} = z_{492} + z_{787}\, z_{366} + z_{788}\, z_{367} + z_{789}\, z_{368}$$

$$z_{809} = l_{\eta p}\, z_{224}$$

$$z_{810} = l_{\eta p}\, z_{242}$$

$$z_{811} = l_{\eta p}\, z_{260}$$

$$z_{812} = z_{210}\, z_{809} + z_{228}\, z_{810} + z_{246}\, z_{811}$$

$$z_{813} = z_{211}\, z_{809} + z_{229}\, z_{810} + z_{247}\, z_{811}$$

$$z_{814} = z_{212}\, z_{809} + z_{230}\, z_{810} + z_{248}\, z_{811}$$

$$z_{815} = z_{215}\, z_{809} + z_{233}\, z_{810} + z_{251}\, z_{811}$$

$$z_{816} = z_{214}\, z_{809} + z_{232}\, z_{810} + z_{250}\, z_{811}$$

$$z_{817} = z_{213}\, z_{809} + z_{231}\, z_{810} + z_{249}\, z_{811}$$

$$z_{818} = -z_{220}\, z_{809} - z_{238}\, z_{810} - z_{256}\, z_{811}$$

$$z_{819} = -z_{221}\, z_{809} - z_{239}\, z_{810} - z_{257}\, z_{811}$$

$$z_{820} = -z_{216}\, z_{809} - z_{234}\, z_{810} - z_{252}\, z_{811}$$

$$z_{821} = -z_{219}\, z_{809} - z_{237}\, z_{810} - z_{255}\, z_{811}$$

$$z_{822} = -z_{218}\, z_{809} - z_{236}\, z_{810} - z_{254}\, z_{811}$$

$$z_{823} = -z_{217}\, z_{809} - z_{235}\, z_{810} - z_{253}\, z_{811}$$

$$z_{824} = z_{222}\, z_{809} + z_{240}\, z_{810} + z_{258}\, z_{811} - z_{481}$$

$$z_{825} = z_{223}\, z_{809} + z_{241}\, z_{810} + z_{259}\, z_{811} - z_{488}$$

$$z_{826} = z_{494} + z_{224}\, z_{809} + z_{242}\, z_{810} + z_{260}\, z_{811}$$

$$z_{827} = z_{496} + z_{227}\, z_{809} + z_{245}\, z_{810} + z_{263}\, z_{811}$$

$$z_{828} = z_{495} + z_{226}\, z_{809} + z_{244}\, z_{810} + z_{262}\, z_{811}$$

$$z_{829} = z_{493} + z_{225}\, z_{809} + z_{243}\, z_{810} + z_{261}\, z_{811}$$

$$z_{830} = z_{497} + z_{809}\, z_{366} + z_{810}\, z_{367} + z_{811}\, z_{368}$$

$$z_{831} = l_{\eta p}\, z_{227}$$

$$z_{832} = l_{\eta p}\, z_{245}$$

$$z_{833} = l_{\eta p}\, z_{263}$$

$$z_{834} = z_{210}\, z_{831} + z_{228}\, z_{832} + z_{246}\, z_{833}$$

$$z_{835} = z_{211}\, z_{831} + z_{229}\, z_{832} + z_{247}\, z_{833}$$

$$z_{836} = z_{212}\, z_{831} + z_{230}\, z_{832} + z_{248}\, z_{833}$$

$$z_{837} = z_{215}\, z_{831} + z_{233}\, z_{832} + z_{251}\, z_{833}$$

$$z_{838} = z_{214}\, z_{831} + z_{232}\, z_{832} + z_{250}\, z_{833}$$

$$z_{839} = z_{213}\, z_{831} + z_{231}\, z_{832} + z_{249}\, z_{833}$$

$$z_{840} = -z_{220}\, z_{831} - z_{238}\, z_{832} - z_{256}\, z_{833}$$
$$z_{841} = -z_{221}\, z_{831} - z_{239}\, z_{832} - z_{257}\, z_{833}$$
$$z_{842} = -z_{216}\, z_{831} - z_{234}\, z_{832} - z_{252}\, z_{833}$$
$$z_{843} = -z_{219}\, z_{831} - z_{237}\, z_{832} - z_{255}\, z_{833}$$
$$z_{844} = -z_{218}\, z_{831} - z_{236}\, z_{832} - z_{254}\, z_{833}$$
$$z_{845} = -z_{217}\, z_{831} - z_{235}\, z_{832} - z_{253}\, z_{833}$$
$$z_{846} = z_{485} + z_{222}\, z_{831} + z_{240}\, z_{832} + z_{258}\, z_{833}$$
$$z_{847} = z_{491} + z_{223}\, z_{831} + z_{241}\, z_{832} + z_{259}\, z_{833}$$
$$z_{848} = z_{496} + z_{224}\, z_{831} + z_{242}\, z_{832} + z_{260}\, z_{833}$$
$$z_{849} = z_{450} + z_{227}\, z_{831} + z_{245}\, z_{832} + z_{263}\, z_{833}$$
$$z_{850} = z_{452} + z_{226}\, z_{831} + z_{244}\, z_{832} + z_{262}\, z_{833}$$
$$z_{851} = z_{451} + z_{225}\, z_{831} + z_{243}\, z_{832} + z_{261}\, z_{833}$$
$$z_{852} = z_{498} + z_{831}\, z_{366} + z_{832}\, z_{367} + z_{833}\, z_{368}$$
$$z_{853} = l_{rp}\, z_{226}$$
$$z_{854} = l_{rp}\, z_{244}$$
$$z_{855} = l_{rp}\, z_{262}$$
$$z_{856} = z_{210}\, z_{853} + z_{228}\, z_{854} + z_{246}\, z_{855}$$
$$z_{857} = z_{211}\, z_{853} + z_{229}\, z_{854} + z_{247}\, z_{855}$$
$$z_{858} = z_{212}\, z_{853} + z_{230}\, z_{854} + z_{248}\, z_{855}$$
$$z_{859} = z_{215}\, z_{853} + z_{233}\, z_{854} + z_{251}\, z_{855}$$
$$z_{860} = z_{214}\, z_{853} + z_{232}\, z_{854} + z_{250}\, z_{855}$$
$$z_{861} = z_{213}\, z_{853} + z_{231}\, z_{854} + z_{249}\, z_{855}$$
$$z_{862} = -z_{220}\, z_{853} - z_{238}\, z_{854} - z_{256}\, z_{855}$$
$$z_{863} = -z_{221}\, z_{853} - z_{239}\, z_{854} - z_{257}\, z_{855}$$
$$z_{864} = -z_{216}\, z_{853} - z_{234}\, z_{854} - z_{252}\, z_{855}$$
$$z_{865} = -z_{219}\, z_{853} - z_{237}\, z_{854} - z_{255}\, z_{855}$$
$$z_{866} = -z_{218}\, z_{853} - z_{236}\, z_{854} - z_{254}\, z_{855}$$
$$z_{867} = -z_{217}\, z_{853} - z_{235}\, z_{854} - z_{253}\, z_{855}$$
$$z_{868} = z_{482} + z_{222}\, z_{853} + z_{240}\, z_{854} + z_{258}\, z_{855}$$
$$z_{869} = z_{489} + z_{223}\, z_{853} + z_{241}\, z_{854} + z_{259}\, z_{855}$$
$$z_{870} = z_{495} + z_{224}\, z_{853} + z_{242}\, z_{854} + z_{260}\, z_{855}$$
$$z_{871} = z_{452} + z_{227}\, z_{853} + z_{245}\, z_{854} + z_{263}\, z_{855}$$
$$z_{872} = z_{454} + z_{226}\, z_{853} + z_{244}\, z_{854} + z_{262}\, z_{855}$$

$$
\begin{aligned}
z_{873} &= z_{455} + z_{225}\, z_{853} + z_{243}\, z_{854} + z_{261}\, z_{855} \\
z_{874} &= z_{499} + z_{853}\, z_{366} + z_{854}\, z_{367} + z_{855}\, z_{368} \\
z_{875} &= l_{rp}\, z_{225} \\
z_{876} &= l_{rp}\, z_{243} \\
z_{877} &= l_{rp}\, z_{261} \\
z_{878} &= z_{210}\, z_{875} + z_{228}\, z_{876} + z_{246}\, z_{877} \\
z_{879} &= z_{211}\, z_{875} + z_{229}\, z_{876} + z_{247}\, z_{877} \\
z_{880} &= z_{212}\, z_{875} + z_{230}\, z_{876} + z_{248}\, z_{877} \\
z_{881} &= z_{215}\, z_{875} + z_{233}\, z_{876} + z_{251}\, z_{877} \\
z_{882} &= z_{214}\, z_{875} + z_{232}\, z_{876} + z_{250}\, z_{877} \\
z_{883} &= z_{213}\, z_{875} + z_{231}\, z_{876} + z_{249}\, z_{877} \\
z_{884} &= -z_{220}\, z_{875} - z_{238}\, z_{876} - z_{256}\, z_{877} \\
z_{885} &= -z_{221}\, z_{875} - z_{239}\, z_{876} - z_{257}\, z_{877} \\
z_{886} &= -z_{216}\, z_{875} - z_{234}\, z_{876} - z_{252}\, z_{877} \\
z_{887} &= -z_{219}\, z_{875} - z_{237}\, z_{876} - z_{255}\, z_{877} \\
z_{888} &= -z_{218}\, z_{875} - z_{236}\, z_{876} - z_{254}\, z_{877} \\
z_{889} &= -z_{217}\, z_{875} - z_{235}\, z_{876} - z_{253}\, z_{877} \\
z_{890} &= z_{480} + z_{222}\, z_{875} + z_{240}\, z_{876} + z_{258}\, z_{877} \\
z_{891} &= z_{487} + z_{223}\, z_{875} + z_{241}\, z_{876} + z_{259}\, z_{877} \\
z_{892} &= z_{493} + z_{224}\, z_{875} + z_{242}\, z_{876} + z_{260}\, z_{877} \\
z_{893} &= z_{451} + z_{227}\, z_{875} + z_{245}\, z_{876} + z_{263}\, z_{877} \\
z_{894} &= z_{455} + z_{226}\, z_{875} + z_{244}\, z_{876} + z_{262}\, z_{877} \\
z_{895} &= z_{457} + z_{225}\, z_{875} + z_{243}\, z_{876} + z_{261}\, z_{877} \\
z_{896} &= z_{500} + z_{875}\, z_{366} + z_{876}\, z_{367} + z_{877}\, z_{368} \\
z_{897} &= z_{369} - z_{522} \\
z_{898} &= z_{370} - z_{544} \\
z_{899} &= z_{371} - z_{566} \\
z_{900} &= z_{374} - z_{588} \\
z_{901} &= z_{376} - z_{610} \\
z_{902} &= z_{377} - z_{632} \\
z_{903} &= z_{378} - z_{654} \\
z_{904} &= z_{379} - z_{676} \\
z_{905} &= z_{380} - z_{698} \\
z_{906} &= z_{381} - z_{720} \\
z_{907} &= z_{382} - z_{742} \\
z_{908} &= z_{383} - z_{764} \\
z_{909} &= z_{384} - z_{786} \\
z_{910} &= z_{385} - z_{808} \\
z_{911} &= z_{386} - z_{830} \\
z_{912} &= z_{387} - z_{852} \\
z_{913} &= z_{388} - z_{874} \\
z_{914} &= z_{389} - z_{896}
\end{aligned}
$$

# 6 Dynamic Equations of the Translational Multi-Lift Model

The following sections present the dynamic equations of the translational model for multi-lift configurations, which is described in the main document [Ber13, pages 100ff.].

## 6.1 Dynamic Equations

The presented dynamic equations are the solution of

$$\ddot{\mathbf{q}} = \mathbf{a} + \mathbf{M}^{-1}\mathbf{A}^t(\mathbf{A}\mathbf{M}^{-1}\mathbf{A}^t)^*(\mathbf{b} - \mathbf{A}\mathbf{a})$$

The equation itself is described in the thesis main document, see [Ber13, page 102]. The coordinates ($\Delta x_i$, $\Delta y_i$, $\Delta z_i$) describe the position difference between the i'th helicopter and the load. The length of the modeled ropes, connecting helicopters and load, correspond to $l_{1,2,3}$. The average rope length is described by $l$. Normally, for simulation $l = l_{1,2,3}$ is assumed, but for initial positions based on real flight data $l$ is only approximately equal to $l_{1,2,3}$. The variable *den* describes a common denominator of the equations. To achieve a compact set of equations the common denominator has been replaced by this variable.

$\Delta x_{h1} = x_{h1} - x_l$

$\Delta y_{h1} = y_{h1} - y_l$

$\Delta z_{h1} = z_{h1} - z_l$

$\Delta x_{h2} = x_{h2} - x_l$

$\Delta y_{h2} = y_{h2} - y_l$

$\Delta z_{h2} = z_{h2} - z_l$

$\Delta x_{h3} = x_{h3} - x_l$

$\Delta y_{h3} = y_{h3} - y_l$

$\Delta z_{h3} = z_{h3} - z_l$

$$
\begin{aligned}
den &= \left(\left((m_{h3}+m_l)\left(\Delta x_{h3}^2+\Delta y_{h3}^2+\Delta z_{h3}^2\right)\left(\left((m_{h1}+m_l)(m_{h2}+m_l)\left(\Delta x_{h1}^2+\right.\right.\right.\right.\\
&\quad \left.\left.\left.\left.\Delta y_{h1}^2+\Delta z_{h1}^2\right)\left(\Delta x_{h2}^2+\Delta y_{h2}^2+\Delta z_{h2}^2\right)\right)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\right.\right.\\
&\quad \left.\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\right)\right)/(m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\\
&\quad \Delta z_{h2}\Delta z_{h3})\left(\left((m_{h1}+m_l)\left(\Delta x_{h1}^2+\Delta y_{h1}^2+\Delta z_{h1}^2\right)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\right.\\
&\quad \left.\left.\Delta z_{h2}\Delta z_{h3})\right)/(m_{h1})-(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\right.\\
&\quad \left.\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)+(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\left((\Delta x_{h1}\Delta x_{h2}+\right.\\
&\quad \left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\left((m_{h2}+\right.\right.\\
&\quad \left.\left.m_l)\left(\Delta x_{h2}^2+\Delta y_{h2}^2+\Delta z_{h2}^2\right)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\right)\Big)/\left(m_l^3\right)\\
l_{h1} &= \sqrt{\Delta x_{h1}^2+\Delta y_{h1}^2+\Delta z_{h1}^2}\\
l_{h2} &= \sqrt{\Delta x_{h2}^2+\Delta y_{h2}^2+\Delta z_{h2}^2}\\
l_{h3} &= \sqrt{\Delta x_{h3}^2+\Delta y_{h3}^2+\Delta z_{h3}^2}\\
l &= (1)/(3)\,(l_{h1}+l_{h2}+l_{h3})\\
\ddot{q}_1 &= \left(\left(\Delta x_{h1}\left(\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\right.\right.\right.\right.\right.\\
&\quad \left.\left.\left.\left.\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\right.\right.\right.\right.\right.\\
&\quad \left.\left.\left.\left.\left.\Delta z_{h1}\Delta z_{h2})\right)/(m_{h3})\right)\left(-\Delta x_{h2}F_{h2,1}^H-F_{h2,2}^H y_{h2}+F_{h2,2}^H y_l-F_{h2,3}^H z_{h2}+\right.\right.\right.\\
&\quad \left.\left.\left.F_{h2,3}^H z_l-m_{h2}\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\right)\right)\right)/(m_{h2})+\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\right.\right.\right.\\
&\quad \left.\left.\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h2}+\right.\right.\right.\\
&\quad \left.\left.\left.m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\right)\left(-\Delta x_{h3}F_{h3,1}^H-F_{h3,2}^H y_{h3}+\right.\\
&\quad \left.F_{h3,2}^H y_l-F_{h3,3}^H z_{h3}+F_{h3,3}^H z_l-m_{h3}\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+\right.\right.\\
&\quad \left.\left.(\dot{z}_{h3}-\dot{z}_l)^2\right)\right)\right)/(m_{h3})+\left(\left(l^4(m_{h2}+m_l)(m_{h3}+m_l)\right)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\right.\\
&\quad \left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\right)\left(-\Delta x_{h1}F_{h1,1}^H-F_{h1,2}^H y_{h1}+\right.\\
&\quad F_{h1,2}^H y_l-F_{h1,3}^H z_{h1}+F_{h1,3}^H z_l-m_{h1}\left((\dot{x}_{h1}-\dot{x}_l)^2+\right.\\
&\quad \left.\left.(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\right)\Big)/\left(den\,m_l^2\right)+F_{h1,1}^H m_{h1}\Big)/\left(m_{h1}^2\right)\\
\ddot{q}_2 &= \left(\left(\Delta y_{h1}\left(\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\right.\right.\right.\right.\right.\\
&\quad \left.\left.\left.\left.\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\right.\right.\right.\right.\right.\\
&\quad \left.\left.\left.\left.\left.\Delta z_{h1}\Delta z_{h2})\right)/(m_{h3})\right)\left(-\Delta x_{h2}F_{h2,1}^H-F_{h2,2}^H y_{h2}+F_{h2,2}^H y_l-F_{h2,3}^H z_{h2}+\right.\right.\right.\\
&\quad \left.\left.\left.F_{h2,3}^H z_l-m_{h2}\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\right)\right)\right)/(m_{h2})+\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\right.\right.\right.\\
&\quad \left.\left.\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h2}+\right.\right.\right.\\
&\quad \left.\left.\left.m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\right)\left(-\Delta x_{h3}F_{h3,1}^H-F_{h3,2}^H y_{h3}+\right.\\
&\quad \left.F_{h3,2}^H y_l-F_{h3,3}^H z_{h3}+F_{h3,3}^H z_l-m_{h3}\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+\right.\right.\\
&\quad \left.\left.(\dot{z}_{h3}-\dot{z}_l)^2\right)\right)\right)/(m_{h3})+\left(\left(l^4(m_{h2}+m_l)(m_{h3}+m_l)\right)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\right.\\
&\quad \left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\right)\left(-\Delta x_{h1}F_{h1,1}^H-F_{h1,2}^H y_{h1}+\right.\\
&\quad F_{h1,2}^H y_l-F_{h1,3}^H z_{h1}+F_{h1,3}^H z_l-m_{h1}\left((\dot{x}_{h1}-\dot{x}_l)^2+\right.\\
&\quad \left.\left.(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\right)\Big)/\left(den\,m_l^2\right)+F_{h1,2}^H m_{h1}\Big)/\left(m_{h1}^2\right)
\end{aligned}
$$

$$\ddot{q}_3 = \big(\Delta z_{h1}\big(\big(m_{h1}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)\big(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+F^H_{h2,3}z_l-m_{h2}\big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\big)\big)/(m_{h2})+\big(m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\big)\big(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+F^H_{h3,3}z_l-m_{h3}\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\big)\big)/(m_{h3})+\big(\big(l^4(m_{h2}+m_l)(m_{h3}+m_l)\big)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\big)\big(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+F^H_{h1,3}z_l-m_{h1}\big((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big)\big)\big)/\big(den\,m_{h1}^2m_l^2\big)+\big(F^H_{h1,3}\big)/(m_{h1})-G$$

$$\ddot{q}_4 = \big(\big(\Delta x_{h2}\big(\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)\big(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+F^H_{h1,3}z_l-m_{h1}\big((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big)\big)/(m_{h1})+\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)\big(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+F^H_{h3,3}z_l-m_{h3}\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\big)\big)/(m_{h3})+\big(\big(l^4(m_{h1}+m_l)(m_{h3}+m_l)\big)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\big)\big(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+F^H_{h2,3}z_l-m_{h2}\big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\big)\big)\big)/\big(den\,m_l^2\big)+F^H_{h2,1}m_{h2}\big)/\big(m_{h2}^2\big)$$

$$\ddot{q}_5 = \big(\big(\Delta y_{h2}\big(\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)\big(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+F^H_{h1,3}z_l-m_{h1}\big((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big)\big)/(m_{h1})+\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)\big(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+F^H_{h3,3}z_l-m_{h3}\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\big)\big)/(m_{h3})+\big(\big(l^4(m_{h1}+m_l)(m_{h3}+m_l)\big)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\big)\big(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+F^H_{h2,3}z_l-m_{h2}\big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\big)\big)\big)/\big(den\,m_l^2\big)+F^H_{h2,2}m_{h2}\big)/\big(m_{h2}^2\big)$$

$$\ddot{q}_6 = \big(\Delta z_{h2}\left(\big(m_{h2}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\right.\right.\right.$$
$$\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+$$
$$\left.\left.\left.\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\right)\left(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+\right.\right.$$
$$\left.\left.F^H_{h1,3}z_l-m_{h1}\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\right)\right)/(m_{h1})+\big(m_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\right.$$
$$\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+$$
$$m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)\left(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+\right.$$
$$F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+F^H_{h3,3}z_l-m_{h3}\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+\right.$$
$$\left.\left.(\dot{z}_{h3}-\dot{z}_l)^2\right)\right)\big)/(m_{h3})+\left(\big(l^4(m_{h1}+m_l)(m_{h3}+m_l)\big)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\right.$$
$$\left.\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\right)\left(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+\right.$$
$$F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+F^H_{h2,3}z_l-m_{h2}\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+\right.$$
$$\left.\left.(\dot{z}_{h2}-\dot{z}_l)^2\right)\right)\big)\big)/\big(den\, m_{h2}^2m_l^2\big)+\big(F^H_{h2,3}\big)/(m_{h2})-G$$

$$\ddot{q}_7 = \big(\big(\Delta x_{h3}\left(\big(m_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\right.\right.\right.$$
$$\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+$$
$$\left.\left.\left.\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\right)\left(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+\right.\right.$$
$$\left.\left.F^H_{h1,3}z_l-m_{h1}\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\right)\right)/(m_{h1})+\big(m_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\right.$$
$$\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+$$
$$m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)\left(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+\right.$$
$$F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+F^H_{h2,3}z_l-m_{h2}\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+\right.$$
$$\left.\left.(\dot{z}_{h2}-\dot{z}_l)^2\right)\right)\big)/(m_{h2})+\left(\big(l^4(m_{h1}+m_l)(m_{h2}+m_l)\big)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\right.$$
$$\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\right)\left(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+\right.$$
$$F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+F^H_{h3,3}z_l-m_{h3}\left((\dot{x}_{h3}-\dot{x}_l)^2+\right.$$
$$\left.\left.(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\right)\right)\big)\big)/\big(den\, m_l^2\big)+F^H_{h3,1}m_{h3}\big)/\big(m_{h3}^2\big)$$

$$\ddot{q}_8 = \big(\big(\Delta y_{h3}\left(\big(m_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\right.\right.\right.$$
$$\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+$$
$$\left.\left.\left.\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\right)\left(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+\right.\right.$$
$$\left.\left.F^H_{h1,3}z_l-m_{h1}\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\right)\right)/(m_{h1})+\big(m_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\right.$$
$$\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+$$
$$m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)\left(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+\right.$$
$$F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+F^H_{h2,3}z_l-m_{h2}\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+\right.$$
$$\left.\left.(\dot{z}_{h2}-\dot{z}_l)^2\right)\right)\big)/(m_{h2})+\left(\big(l^4(m_{h1}+m_l)(m_{h2}+m_l)\big)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\right.$$
$$\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\right)\left(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+\right.$$
$$F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+F^H_{h3,3}z_l-m_{h3}\left((\dot{x}_{h3}-\dot{x}_l)^2+\right.$$
$$\left.\left.(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\right)\right)\big)\big)/\big(den\, m_l^2\big)+F^H_{h3,2}m_{h3}\big)/\big(m_{h3}^2\big)$$

$$\ddot{q}_9 = \big(\Delta z_{h3}\left(\left(m_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\right.\right.\right.$$
$$\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.$$
$$\left.\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\big)\left(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+\right.$$
$$F^H_{h1,3}z_l-m_{h1}\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\big)\big)/(m_{h1})+\big(m_{h3}\left((\Delta x_{h1}\Delta x_{h2}+$$
$$\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\left(l^2(m_{h1}+\right.$$
$$m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)\left(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+\right.$$
$$F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+F^H_{h2,3}z_l-m_{h2}\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+\right.$$
$$\left.\left.(\dot{z}_{h2}-\dot{z}_l)^2\right)\right)\big)/(m_{h2})+\left(\left(l^4(m_{h1}+m_l)(m_{h2}+m_l)\right)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\right.$$
$$\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\right)\left(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+\right.$$
$$F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+F^H_{h3,3}z_l-m_{h3}\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+\right.$$
$$\left.\left.\left.(\dot{z}_{h3}-\dot{z}_l)^2\right)\right)\right)\big)/\big(den\, m^2_{h3}m^2_l\big)+\left(F^H_{h3,3}\right)/(m_{h3})-G$$

$$\ddot{q}_{10} = -\Big(\Big(\big(\Delta x_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.$$
$$\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\big)+$$
$$\Delta x_{h2}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.$$
$$\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)/(m_{h3})\big)+$$
$$\Delta x_{h1}\left(\left(l^4(m_{h2}+m_l)(m_{h3}+m_l)\right)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\right.$$
$$\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\right)\big)\left(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+\right.$$
$$F^H_{h1,3}z_l-m_{h1}\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\big)\big)/(m_{h1})+$$
$$\Big(\big(\Delta x_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.$$
$$\Delta z_{h1}\Delta z_{h3})-\left(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)/(m_{h1})\big)+$$
$$\Delta x_{h1}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.$$
$$\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)/(m_{h3})\big)+$$
$$\Delta x_{h2}\left(\left(l^4(m_{h1}+m_l)(m_{h3}+m_l)\right)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\right.$$
$$\left.\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\right)\big)\left(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+\right.$$
$$F^H_{h2,3}z_l-m_{h2}\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\right)\big)\big)/(m_{h2})+$$
$$\Big(\big(\Delta x_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.$$
$$\Delta z_{h1}\Delta z_{h3})-\left(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)/(m_{h1})\big)+$$
$$\Delta x_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.$$
$$\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\big)+$$
$$\Delta x_{h3}\left(\left(l^4(m_{h1}+m_l)(m_{h2}+m_l)\right)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\right.$$
$$\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\right)\big)\left(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+\right.$$
$$\left.F^H_{h3,3}z_l-m_{h3}\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\right)\big)\big)/(m_{h3})\big)/\big(den\, m^3_l\big)$$

$$
\begin{aligned}
\ddot{q}_{11} = &- \Big(\Big(\Big(\Delta y_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\Big)+\\
&\Delta y_{h2}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)/(m_{h3})\right)+\\
&\Delta y_{h1}\left(\left(l^4(m_{h2}+m_l)(m_{h3}+m_l)\right)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\right.\\
&\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\right)\Big)\left(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+\right.\\
&\left.F^H_{h1,3}z_l-m_{h1}\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\right)\Big)/(m_{h1})+\\
&\Big(\Big(\Delta y_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h1}\Delta z_{h3})-\left(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)/(m_{h1})\Big)+\\
&\Delta y_{h1}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)/(m_{h3})\right)+\\
&\Delta y_{h2}\left(\left(l^4(m_{h1}+m_l)(m_{h3}+m_l)\right)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\right.\\
&\left.\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\right)\Big)\left(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+\right.\\
&\left.F^H_{h2,3}z_l-m_{h2}\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\right)\right)\Big)/(m_{h2})+\\
&\Big(\Big(\Delta y_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h1}\Delta z_{h3})-\left(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)/(m_{h1})\Big)+\\
&\Delta y_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\right)+\\
&\Delta y_{h3}\left(\left(l^4(m_{h1}+m_l)(m_{h2}+m_l)\right)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\right.\\
&\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\right)\Big)\left(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+\right.\\
&\left.F^H_{h3,3}z_l-m_{h3}\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\right)\right)\Big)/(m_{h3})\Big)/\left(den\, m_l^3\right)
\end{aligned}
$$

$$
\begin{aligned}
\ddot{q}_{12} = &- \Big(\Big(\Big(\Delta z_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\Big)+\\
&\Delta z_{h2}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)/(m_{h3})\Big)+\\
&\Delta z_{h1}\left(\left(l^4(m_{h2}+m_l)(m_{h3}+m_l)\right)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\right.\\
&\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\right)\Big)\left(-\Delta x_{h1}F^H_{h1,1}-F^H_{h1,2}y_{h1}+F^H_{h1,2}y_l-F^H_{h1,3}z_{h1}+\right.\\
&\left.F^H_{h1,3}z_l-m_{h1}\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\right)/(m_{h1})+\\
&\Big(\Big(\Delta z_{h3}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h1}\Delta z_{h3})-\left(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)/(m_{h1})\Big)+\\
&\Delta z_{h1}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)/(m_{h3})\Big)+\\
&\Delta z_{h2}\left(\left(l^4(m_{h1}+m_l)(m_{h3}+m_l)\right)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\right.\\
&\left.\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\right)\Big)\left(-\Delta x_{h2}F^H_{h2,1}-F^H_{h2,2}y_{h2}+F^H_{h2,2}y_l-F^H_{h2,3}z_{h2}+\right.\\
&\left.F^H_{h2,3}z_l-m_{h2}\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\right)\right)/(m_{h2})+\\
&\Big(\Big(\Delta z_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h1}\Delta z_{h3})-\left(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)/(m_{h1})\Big)+\\
&\Delta z_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\left(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\Big)+\\
&\Delta z_{h3}\left(\left(l^4(m_{h1}+m_l)(m_{h2}+m_l)\right)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\right.\\
&\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\right)\Big)\left(-\Delta x_{h3}F^H_{h3,1}-F^H_{h3,2}y_{h3}+F^H_{h3,2}y_l-F^H_{h3,3}z_{h3}+\right.\\
&\left.F^H_{h3,3}z_l-m_{h3}\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\right)\right)/(m_{h3})\Big)/\left(den\, m_l^3\right)-G
\end{aligned}
$$

## 6.2 Inverse Dynamic Equations

The solution of the inverse dynamic equations is calculated using Singular Value Decomposition. Therefore, the dynamic equations are rewritten into

$$
\begin{aligned}
0 &= \mathbf{a}+\mathbf{M}^{-1}\mathbf{A}^t(\mathbf{A}\mathbf{M}^{-1}\mathbf{A}^t)^*(\mathbf{b}-\mathbf{A}\mathbf{a})-\ddot{\mathbf{q}}\\
0 &= \mathbf{C}\,\mathbf{x}-\mathbf{d}
\end{aligned}
$$

The equation itself is described in the thesis main document, see [Ber13, page 103]. The matrix $\mathbf{C}$ and the vector $\mathbf{d}$ are given by the following equations

$$\Delta x_{h1} = x_{h1}-x_l$$

$$\Delta y_{h1} = y_{h1}-y_l$$

$$\Delta z_{h1} = z_{h1}-z_l$$

$$\Delta x_{h2} = x_{h2}-x_l$$

$$\Delta y_{h2} = y_{h2}-y_l$$

$$\Delta z_{h2} = z_{h2} - z_l$$

$$\Delta x_{h3} = x_{h3} - x_l$$

$$\Delta y_{h3} = y_{h3} - y_l$$

$$\Delta z_{h3} = z_{h3} - z_l$$

$$\begin{aligned} den = &\left(\left((m_{h3}+m_l)\left(\Delta x_{h3}^2+\Delta y_{h3}^2+\Delta z_{h3}^2\right)\left(\left((m_{h1}+m_l)(m_{h2}+m_l)\left(\Delta x_{h1}^2+\right.\right.\right.\right.\\ &\left.\left.\left.\left.\Delta y_{h1}^2+\Delta z_{h1}^2\right)\left(\Delta x_{h2}^2+\Delta y_{h2}^2+\Delta z_{h2}^2\right)\right)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\right.\right.\\ &\left.\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\right)\right)/(m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\\ &\Delta z_{h2}\Delta z_{h3})\left(\left((m_{h1}+m_l)\left(\Delta x_{h1}^2+\Delta y_{h1}^2+\Delta z_{h1}^2\right)(\Delta x_{h2}\Delta x_{h3}+\right.\right.\\ &\left.\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)/(m_{h1})-(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\ &\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)+(\Delta x_{h1}\Delta x_{h3}+\\ &\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\right.\\ &\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\left((m_{h2}+m_l)\left(\Delta x_{h2}^2+\Delta y_{h2}^2+\right.\right.\right.\\ &\left.\left.\left.\Delta z_{h2}^2\right)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)/(m_{h2})\right)\Big)/\left(m_l^3\right) \end{aligned}$$

$$l_{h1} = \sqrt{\Delta x_{h1}^2+\Delta y_{h1}^2+\Delta z_{h1}^2}$$

$$l_{h2} = \sqrt{\Delta x_{h2}^2+\Delta y_{h2}^2+\Delta z_{h2}^2}$$

$$l_{h3} = \sqrt{\Delta x_{h3}^2+\Delta y_{h3}^2+\Delta z_{h3}^2}$$

$$l = (1)/(3)\,(l_{h1}+l_{h2}+l_{h3})$$

$$\begin{aligned} C(1,1) = &\left(den\, m_{h1}m_{h2}m_{h3}m_l^2+\Delta x_{h1}^2\left(m_{h2}m_{h3}\left((\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\right.\right.\right.\\ &\left.\left.\left.\left.\Delta z_{h2}\Delta z_{h3})^2-l^4\right)-l^4m_l(m_{h2}+m_{h3})+l^4\left(-m_l^2\right)\right)\right)/\left(den\, m_{h1}^2m_{h2}m_{h3}m_l^2\right) \end{aligned}$$

$$\begin{aligned} C(1,2) = &\left(\Delta x_{h1}(y_{h1}-y_l)\left(m_{h2}m_{h3}\left((\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\right.\right.\\ &\left.\left.\left.\Delta z_{h2}\Delta z_{h3})^2-l^4\right)-l^4m_l(m_{h2}+m_{h3})+l^4\left(-m_l^2\right)\right)\right)/\left(den\, m_{h1}^2m_{h2}m_{h3}m_l^2\right) \end{aligned}$$

$$\begin{aligned} C(1,3) = &\left(\Delta x_{h1}(z_{h1}-z_l)\left(m_{h2}m_{h3}\left((\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\right.\right.\\ &\left.\left.\left.\Delta z_{h2}\Delta z_{h3})^2-l^4\right)-l^4m_l(m_{h2}+m_{h3})+l^4\left(-m_l^2\right)\right)\right)/\left(den\, m_{h1}^2m_{h2}m_{h3}m_l^2\right) \end{aligned}$$

$$\begin{aligned} C(1,4) = &\left(\Delta x_{h1}\Delta x_{h2}\left(l^2m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})-m_{h3}\left((\Delta x_{h1}\Delta x_{h3}+\right.\right.\right.\\ &\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\\ &\left.\left.\left.\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^2\right) \end{aligned}$$

$$\begin{aligned} C(1,5) = -&\left(\Delta x_{h1}(y_{h2}-y_l)\left(m_{h3}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\right.\right.\\ &\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\\ &\left.\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)-l^2m_l(\Delta x_{h1}\Delta x_{h2}+\right.\\ &\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)\Big)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^2\right) \end{aligned}$$

$$C(1,6) = -\big(\Delta x_{h1}(z_{h2}-z_l)\big(m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(1,7) = \big(\Delta x_{h1}\Delta x_{h3}\big(l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(1,8) = -\big(\Delta x_{h1}(y_{h3}-y_l)\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(1,9) = -\big(\Delta x_{h1}(z_{h3}-z_l)\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(2,1) = \big(\Delta x_{h1}\Delta y_{h1}\big(m_{h2}m_{h3}\big((\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2-l^4\big)-l^4 m_l(m_{h2}+m_{h3})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}^2 m_{h2}m_{h3}m_l^2\big)$$

$$C(2,2) = \big(den\, m_{h1}m_{h2}m_{h3}m_l^2+\Delta y_{h1}(y_{h1}-y_l)\big(m_{h2}m_{h3}\big((\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2-l^4\big)-l^4 m_l(m_{h2}+m_{h3})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}^2 m_{h2}m_{h3}m_l^2\big)$$

$$C(2,3) = \big(\Delta y_{h1}(z_{h1}-z_l)\big(m_{h2}m_{h3}\big((\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2-l^4\big)-l^4 m_l(m_{h2}+m_{h3})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}^2 m_{h2}m_{h3}m_l^2\big)$$

$$C(2,4) = \big(\Delta x_{h2}\Delta y_{h1}\big(l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})-m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(2,5) = -\big(\Delta y_{h1}(y_{h2}-y_l)\big(m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(2,6) = -\big(\Delta y_{h1}(z_{h2}-z_l)\big(m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(2,7) = \big(\Delta x_{h3}\Delta y_{h1}\left(l^2 m_l(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3}) - m_{h2}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right)\right)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(2,8) = -\big(\Delta y_{h1}(y_{h3} - y_l)\left(m_{h2}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right) - l^2 m_l(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(2,9) = -\big(\Delta y_{h1}(z_{h3} - z_l)\left(m_{h2}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right) - l^2 m_l(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(3,1) = \big(\Delta x_{h1}\Delta z_{h1}\left(m_{h2}m_{h3}\left((\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})^2 - l^4\right) - l^4 m_l(m_{h2} + m_{h3}) + l^4\left(-m_l^2\right)\right)\big)/\big(den\, m_{h1}^2 m_{h2}m_{h3}m_l^2\big)$$

$$C(3,2) = \big(\Delta z_{h1}(y_{h1} - y_l)\left(m_{h2}m_{h3}\left((\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})^2 - l^4\right) - l^4 m_l(m_{h2} + m_{h3}) + l^4\left(-m_l^2\right)\right)\big)/\big(den\, m_{h1}^2 m_{h2}m_{h3}m_l^2\big)$$

$$C(3,3) = \big(den\, m_{h1}m_{h2}m_{h3}m_l^2 + \Delta z_{h1}(z_{h1} - z_l)\left(m_{h2}m_{h3}\left((\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})^2 - l^4\right) - l^4 m_l(m_{h2} + m_{h3}) + l^4\left(-m_l^2\right)\right)\big)/\big(den\, m_{h1}^2 m_{h2}m_{h3}m_l^2\big)$$

$$C(3,4) = \big(\Delta x_{h2}\Delta z_{h1}\left(l^2 m_l(\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) - m_{h3}\left((\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right)\right)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(3,5) = -\big(\Delta z_{h1}(y_{h2} - y_l)\left(m_{h3}\left((\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(3,6) = -\big(\Delta z_{h1}(z_{h2} - z_l)\left(m_{h3}\left((\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(3,7) = \big(\Delta x_{h3}\Delta z_{h1}\left(l^2 m_l(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3}) - m_{h2}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right)\right)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(3,8) = -\big(\Delta z_{h1}(y_{h3}-y_l)\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(3,9) = -\big(\Delta z_{h1}(z_{h3}-z_l)\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(4,1) = \big(\Delta x_{h1}\Delta x_{h2}\big(l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})-m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(4,2) = -\big(\Delta x_{h2}(y_{h1}-y_l)\big(m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(4,3) = -\big(\Delta x_{h2}(z_{h1}-z_l)\big(m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(4,4) = \big(m_l^2\big(den\, m_{h1}m_{h2}m_{h3}-\Delta x_{h2}^2 l^4\big)+\Delta x_{h2}^2 m_{h1}m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2-l^4\big)-\Delta x_{h2}^2 l^4 m_l(m_{h1}+m_{h3})\big)/\big(den\, m_{h1}m_{h2}^2m_{h3}m_l^2\big)$$

$$C(4,5) = \big(\Delta x_{h2}(y_{h2}-y_l)\big(m_{h1}m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2-l^4\big)-l^4 m_l(m_{h1}+m_{h3})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}m_{h2}^2m_{h3}m_l^2\big)$$

$$C(4,6) = \big(\Delta x_{h2}(z_{h2}-z_l)\big(m_{h1}m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2-l^4\big)-l^4 m_l(m_{h1}+m_{h3})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}m_{h2}^2m_{h3}m_l^2\big)$$

$$C(4,7) = \big(\Delta x_{h2}\Delta x_{h3}\big(l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(4,8) = -\big(\Delta x_{h2}(y_{h3}-y_l)\big(m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(4,9) = -\big(\Delta x_{h2}(z_{h3}-z_l)\big(m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(5,1) = \big(\Delta x_{h1}\Delta y_{h2}\big(l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})-m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(5,2) = -\big(\Delta y_{h2}(y_{h1}-y_l)\big(m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(5,3) = -\big(\Delta y_{h2}(z_{h1}-z_l)\big(m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(5,4) = \big(\Delta x_{h2}\Delta y_{h2}\big(m_{h1}m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2-l^4\big)-l^4 m_l(m_{h1}+m_{h3})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}m_{h2}^2m_{h3}m_l^2\big)$$

$$C(5,5) = \big(den\, m_{h1}m_{h2}m_{h3}m_l^2+\Delta y_{h2}(y_{h2}-y_l)\big(m_{h1}m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2-l^4\big)-l^4 m_l(m_{h1}+m_{h3})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}m_{h2}^2m_{h3}m_l^2\big)$$

$$C(5,6) = \big(\Delta y_{h2}(z_{h2}-z_l)\big(m_{h1}m_{h3}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2-l^4\big)-l^4 m_l(m_{h1}+m_{h3})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}m_{h2}^2m_{h3}m_l^2\big)$$

$$C(5,7) = \big(\Delta x_{h3}\Delta y_{h2}\big(l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(5,8) = -\big(\Delta y_{h2}(y_{h3}-y_l)\big(m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(5,9) = -\big(\Delta y_{h2}(z_{h3}-z_l)\big(m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(6,1) = \big(\Delta x_{h1}\Delta z_{h2}\left(l^2 m_l(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2}) - m_{h3}\left((\Delta x_{h1}\Delta x_{h3}+\right.\right.$$
$$\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+$$
$$\left.\left.\Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)\right)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(6,2) = -\big(\Delta z_{h2}(y_{h1}-y_l)\left(m_{h3}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\right.$$
$$\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h2}+$$
$$\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta x_{h1}\Delta x_{h2}+$$
$$\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(6,3) = -\big(\Delta z_{h2}(z_{h1}-z_l)\left(m_{h3}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\right.$$
$$\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h2}+$$
$$\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta x_{h1}\Delta x_{h2}+$$
$$\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(6,4) = \big(\Delta x_{h2}\Delta z_{h2}\left(m_{h1}m_{h3}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\right.$$
$$\left.\Delta z_{h1}\Delta z_{h3})^2 - l^4\right) - l^4 m_l(m_{h1}+m_{h3}) + l^4\left(-m_l^2\right)\big)\big)\big/\big(den\, m_{h1}m_{h2}^2m_{h3}m_l^2\big)$$

$$C(6,5) = \big(\Delta z_{h2}(y_{h2}-y_l)\left(m_{h1}m_{h3}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\right.$$
$$\left.\Delta z_{h1}\Delta z_{h3})^2 - l^4\right) - l^4 m_l(m_{h1}+m_{h3}) + l^4\left(-m_l^2\right)\big)\big)\big/\big(den\, m_{h1}m_{h2}^2m_{h3}m_l^2\big)$$

$$C(6,6) = \big(den\, m_{h1}m_{h2}m_{h3}m_l^2 + \Delta z_{h2}(z_{h2}-z_l)\left(m_{h1}m_{h3}\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\right.\right.$$
$$\left.\Delta z_{h1}\Delta z_{h3})^2 - l^4\right) - l^4 m_l(m_{h1}+m_{h3}) + l^4\left(-m_l^2\right)\big)\big)\big/\big(den\, m_{h1}m_{h2}^2m_{h3}m_l^2\big)$$

$$C(6,7) = \big(\Delta x_{h3}\Delta z_{h2}\left(l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3}) - m_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\right.\right.$$
$$\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+$$
$$\left.\left.\Delta z_{h1}\Delta z_{h3}) - l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)\right)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(6,8) = -\big(\Delta z_{h2}(y_{h3}-y_l)\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\right.\right.$$
$$\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3}) - l^2(\Delta x_{h2}\Delta x_{h3}+$$
$$\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right) - l^2 m_l(\Delta x_{h2}\Delta x_{h3}+$$
$$\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(6,9) = -\big(\Delta z_{h2}(z_{h3}-z_l)\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\right.\right.$$
$$\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3}) - l^2(\Delta x_{h2}\Delta x_{h3}+$$
$$\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right) - l^2 m_l(\Delta x_{h2}\Delta x_{h3}+$$
$$\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(7,1) = \big(\Delta x_{h1}\Delta x_{h3}\left(l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3}) - m_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\right.\right.$$
$$\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+$$
$$\left.\left.\Delta z_{h2}\Delta z_{h3}) - l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)\right)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(7,2) = -\left(\Delta x_{h3}(y_{h1}-y_l)\left(m_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^2\right)$$

$$C(7,3) = -\left(\Delta x_{h3}(z_{h1}-z_l)\left(m_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^2\right)$$

$$C(7,4) = \left(\Delta x_{h2}\Delta x_{h3}\left(l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-m_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^2\right)$$

$$C(7,5) = -\left(\Delta x_{h3}(y_{h2}-y_l)\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)-l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^2\right)$$

$$C(7,6) = -\left(\Delta x_{h3}(z_{h2}-z_l)\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)-l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^2\right)$$

$$C(7,7) = \left(m_l^2\left(den\, m_{h1}m_{h2}m_{h3}-\Delta x_{h3}^2 l^4\right)+\Delta x_{h3}^2 m_{h1}m_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2-l^4\right)-\Delta x_{h3}^2 l^4 m_l(m_{h1}+m_{h2})\right)/\left(den\, m_{h1}m_{h2}m_{h3}^2 m_l^2\right)$$

$$C(7,8) = \left(\Delta x_{h3}(y_{h3}-y_l)\left(m_{h1}m_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2-l^4\right)-l^4 m_l(m_{h1}+m_{h2})+l^4\left(-m_l^2\right)\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}^2 m_l^2\right)$$

$$C(7,9) = \left(\Delta x_{h3}(z_{h3}-z_l)\left(m_{h1}m_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2-l^4\right)-l^4 m_l(m_{h1}+m_{h2})+l^4\left(-m_l^2\right)\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}^2 m_l^2\right)$$

$$C(8,1) = \left(\Delta x_{h1}\Delta y_{h3}\left(l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-m_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^2\right)$$

$$C(8,2) = -\left(\Delta y_{h3}(y_{h1}-y_l)\left(m_{h2}\left((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\right)\right)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^2\right)$$

$$C(8,3) = -\big(\Delta y_{h3}(z_{h1}-z_l)\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(8,4) = \big(\Delta x_{h2}\Delta y_{h3}\big(l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(8,5) = -\big(\Delta y_{h3}(y_{h2}-y_l)\big(m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(8,6) = -\big(\Delta y_{h3}(z_{h2}-z_l)\big(m_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-l^2(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(8,7) = \big(\Delta x_{h3}\Delta y_{h3}\big(m_{h1}m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2-l^4\big)-l^4 m_l(m_{h1}+m_{h2})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}^2m_l^2\big)$$

$$C(8,8) = \big(den\, m_{h1}m_{h2}m_{h3}m_l^2+\Delta y_{h3}(y_{h3}-y_l)\big(m_{h1}m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2-l^4\big)-l^4 m_l(m_{h1}+m_{h2})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}^2m_l^2\big)$$

$$C(8,9) = \big(\Delta y_{h3}(z_{h3}-z_l)\big(m_{h1}m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2-l^4\big)-l^4 m_l(m_{h1}+m_{h2})+l^4\left(-m_l^2\right)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}^2m_l^2\big)$$

$$C(9,1) = \big(\Delta x_{h1}\Delta z_{h3}\big(l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(9,2) = -\big(\Delta z_{h3}(y_{h1}-y_l)\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(9,3) = -\big(\Delta z_{h3}(z_{h1}-z_l)\big(m_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-l^2(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)-l^2 m_l(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)\big)/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(9,4) = \big(\Delta x_{h2}\Delta z_{h3}\left(l^2 m_l(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - m_{h1}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3}) - l^2(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right)\right)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(9,5) = -\big(\Delta z_{h3}(y_{h2} - y_l)\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3}) - l^2(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) - l^2 m_l(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(9,6) = -\big(\Delta z_{h3}(z_{h2} - z_l)\left(m_{h1}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3} + \Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3}) - l^2(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) - l^2 m_l(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^2\big)$$

$$C(9,7) = \big(\Delta x_{h3}\Delta z_{h3}\left(m_{h1}m_{h2}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})^2 - l^4\right) - l^4 m_l(m_{h1} + m_{h2}) + l^4\left(-m_l^2\right)\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}^2m_l^2\big)$$

$$C(9,8) = \big(\Delta z_{h3}(y_{h3} - y_l)\left(m_{h1}m_{h2}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})^2 - l^4\right) - l^4 m_l(m_{h1} + m_{h2}) + l^4\left(-m_l^2\right)\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}^2m_l^2\big)$$

$$C(9,9) = \big(den\, m_{h1}m_{h2}m_{h3}m_l^2 + \Delta z_{h3}(z_{h3} - z_l)\left(m_{h1}m_{h2}\left((\Delta x_{h1}\Delta x_{h2} + \Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})^2 - l^4\right) - l^4 m_l(m_{h1} + m_{h2}) + l^4\left(-m_l^2\right)\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}^2m_l^2\big)$$

$$C(10,1) = \big(\Delta x_{h1}\left(\Delta x_{h1}\left(l^2 m_l\left(\Delta x_{h2}^2(-m_{h2}) - \Delta x_{h3}^2 m_{h3} + l^2(m_{h2} + m_{h3})\right) + m_{h2}m_{h3}\left((\Delta x_{h2} - l)(\Delta x_{h2} + l)(\Delta x_{h3} - l)(\Delta x_{h3} + l) - (\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})^2\right) + l^4 m_l^2\right) + \Delta x_{h2}^2\Delta x_{h3}m_{h2}m_{h3}(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3}) + \Delta x_{h2}m_{h2}\left(m_{h3}\left(\Delta x_{h3}^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) + (\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) + \Delta x_{h3}m_{h3}\left(m_{h2}\left((\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right) - l^2 m_l(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right)\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^3\big)$$

$$C(10,2) = \big((y_{h1} - y_l)\left(\Delta x_{h1}\left(l^2 m_l\left(\Delta x_{h2}^2(-m_{h2}) - \Delta x_{h3}^2 m_{h3} + l^2(m_{h2} + m_{h3})\right) + m_{h2}m_{h3}\left((\Delta x_{h2} - l)(\Delta x_{h2} + l)(\Delta x_{h3} - l)(\Delta x_{h3} + l) - (\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})^2\right) + l^4 m_l^2\right) + \Delta x_{h2}^2\Delta x_{h3}m_{h2}m_{h3}(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3}) + \Delta x_{h2}m_{h2}\left(m_{h3}\left(\Delta x_{h3}^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) + (\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) + \Delta x_{h3}m_{h3}\left(m_{h2}\left((\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right) - l^2 m_l(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right)\right)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^3\big)$$

$$C(10,3) = \big((z_{h1} - z_l)\left(\Delta x_{h1}\left(l^2 m_l\left(\Delta x_{h2}^2(-m_{h2}) - \Delta x_{h3}^2 m_{h3} + l^2(m_{h2} + m_{h3})\right) + m_{h2}m_{h3}\left((\Delta x_{h2} - l)(\Delta x_{h2} + l)(\Delta x_{h3} - l)(\Delta x_{h3} + l) - (\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})^2\right) + l^4 m_l^2\right) + \Delta x_{h2}^2 \Delta x_{h3} m_{h2} m_{h3}(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3}) + \Delta x_{h2} m_{h2}\left(m_{h3}\left(\Delta x_{h3}^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) + (\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) + \Delta x_{h3} m_{h3}\left(m_{h2}\left((\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right) - l^2 m_l(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\right)\right)\big) / \left(den\, m_{h1}m_{h2}m_{h3}m_l^3\right)$$

$$C(10,4) = \big(\Delta x_{h2}\left(\Delta x_{h1}^2 m_{h1}\left(\Delta x_{h2}\left(\Delta x_{h3}^2 m_{h3} - l^2(m_{h3} + m_l)\right) + \Delta x_{h3} m_{h3}(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) + \Delta x_{h1} m_{h1}\left(m_{h3}\left(\Delta x_{h3}^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) + (\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) + l^2 m_l\left(\Delta x_{h2}\left(l^2(m_{h1} + m_{h3}) - \Delta x_{h3}^2 m_{h3}\right) - \Delta x_{h3} m_{h3}(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) + m_{h1}m_{h3}\left((\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta x_{h3}(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) - \Delta x_{h2}(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})) - \Delta x_{h3} l^2(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) + \Delta x_{h2} l^4\right) + \Delta x_{h2} l^4 m_l^2\big)\big) / \left(den\, m_{h1}m_{h2}m_{h3}m_l^3\right)$$

$$C(10,5) = \big((y_{h2} - y_l)\left(\Delta x_{h1}^2 m_{h1}\left(\Delta x_{h2}\left(\Delta x_{h3}^2 m_{h3} - l^2(m_{h3} + m_l)\right) + \Delta x_{h3} m_{h3}(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) + \Delta x_{h1} m_{h1}\left(m_{h3}\left(\Delta x_{h3}^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) + (\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) + l^2 m_l\left(\Delta x_{h2}\left(l^2(m_{h1} + m_{h3}) - \Delta x_{h3}^2 m_{h3}\right) - \Delta x_{h3} m_{h3}(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) + m_{h1}m_{h3}\left((\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta x_{h3}(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) - \Delta x_{h2}(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})) - \Delta x_{h3} l^2(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) + \Delta x_{h2} l^4\right) + \Delta x_{h2} l^4 m_l^2\big)\big) / \left(den\, m_{h1}m_{h2}m_{h3}m_l^3\right)$$

$$C(10,6) = \big((z_{h2} - z_l)\left(\Delta x_{h1}^2 m_{h1}\left(\Delta x_{h2}\left(\Delta x_{h3}^2 m_{h3} - l^2(m_{h3} + m_l)\right) + \Delta x_{h3} m_{h3}(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) + \Delta x_{h1} m_{h1}\left(m_{h3}\left(\Delta x_{h3}^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) + (\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) - l^2 m_l(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})\right) + l^2 m_l\left(\Delta x_{h2}\left(l^2(m_{h1} + m_{h3}) - \Delta x_{h3}^2 m_{h3}\right) - \Delta x_{h3} m_{h3}(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) + m_{h1}m_{h3}\left((\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})(\Delta x_{h3}(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2}) - \Delta x_{h2}(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})) - \Delta x_{h3} l^2(\Delta x_{h2}\Delta x_{h3} + \Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) + \Delta x_{h2} l^4\right) + \Delta x_{h2} l^4 m_l^2\big)\big) / \left(den\, m_{h1}m_{h2}m_{h3}m_l^3\right)$$

$$
\begin{aligned}
C(10,7) = \big(&\Delta x_{h3}\left(\Delta x_{h1}^2 m_{h1}\left(\Delta x_{h2}^2\Delta x_{h3}m_{h2} + \Delta x_{h2}m_{h2}(\Delta y_{h2}\Delta y_{h3} + \right.\right.\\
&\Delta z_{h2}\Delta z_{h3}) - \Delta x_{h3}l^2(m_{h2}+m_l)\big) + \Delta x_{h1}m_{h1}\left(m_{h2}\left(\Delta x_{h2}^2(\Delta y_{h1}\Delta y_{h3} + \right.\right.\\
&\Delta z_{h1}\Delta z_{h3}) + (\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h3} + \\
&\Delta z_{h1}\Delta z_{h3})\big) - l^2 m_l(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\big) + l^2 m_l\left(\Delta x_{h3}\left(l^2(m_{h1} + \right.\right.\\
&\left.\left.m_{h2}) - \Delta x_{h2}^2 m_{h2}\right) - \Delta x_{h2}m_{h2}(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) + \\
&m_{h1}m_{h2}\left(-(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h3}(\Delta y_{h1}\Delta y_{h2} + \right.\\
&\Delta z_{h1}\Delta z_{h2}) - \Delta x_{h2}(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})) - \Delta x_{h2}l^2(\Delta x_{h2}\Delta x_{h3} + \\
&\left.\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) + \Delta x_{h3}l^4\right) + \Delta x_{h3}l^4 m_l^2)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(10,8) = \big((&y_{h3} - y_l)\left(\Delta x_{h1}^2 m_{h1}\left(\Delta x_{h2}^2\Delta x_{h3}m_{h2} + \Delta x_{h2}m_{h2}(\Delta y_{h2}\Delta y_{h3} + \right.\right.\\
&\Delta z_{h2}\Delta z_{h3}) - \Delta x_{h3}l^2(m_{h2}+m_l)\big) + \Delta x_{h1}m_{h1}\left(m_{h2}\left(\Delta x_{h2}^2(\Delta y_{h1}\Delta y_{h3} + \right.\right.\\
&\Delta z_{h1}\Delta z_{h3}) + (\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h3} + \\
&\Delta z_{h1}\Delta z_{h3})\big) - l^2 m_l(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\big) + l^2 m_l\left(\Delta x_{h3}\left(l^2(m_{h1} + \right.\right.\\
&\left.\left.m_{h2}) - \Delta x_{h2}^2 m_{h2}\right) - \Delta x_{h2}m_{h2}(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) + \\
&m_{h1}m_{h2}\left(-(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h3}(\Delta y_{h1}\Delta y_{h2} + \right.\\
&\Delta z_{h1}\Delta z_{h2}) - \Delta x_{h2}(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})) - \Delta x_{h2}l^2(\Delta x_{h2}\Delta x_{h3} + \\
&\left.\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) + \Delta x_{h3}l^4\right) + \Delta x_{h3}l^4 m_l^2)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(10,9) = \big((&z_{h3} - z_l)\left(\Delta x_{h1}^2 m_{h1}\left(\Delta x_{h2}^2\Delta x_{h3}m_{h2} + \Delta x_{h2}m_{h2}(\Delta y_{h2}\Delta y_{h3} + \right.\right.\\
&\Delta z_{h2}\Delta z_{h3}) - \Delta x_{h3}l^2(m_{h2}+m_l)\big) + \Delta x_{h1}m_{h1}\left(m_{h2}\left(\Delta x_{h2}^2(\Delta y_{h1}\Delta y_{h3} + \right.\right.\\
&\Delta z_{h1}\Delta z_{h3}) + (\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) - l^2(\Delta y_{h1}\Delta y_{h3} + \\
&\Delta z_{h1}\Delta z_{h3})\big) - l^2 m_l(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})\big) + l^2 m_l\left(\Delta x_{h3}\left(l^2(m_{h1} + \right.\right.\\
&\left.\left.m_{h2}) - \Delta x_{h2}^2 m_{h2}\right) - \Delta x_{h2}m_{h2}(\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})\right) + \\
&m_{h1}m_{h2}\left(-(\Delta y_{h1}\Delta y_{h2} + \Delta z_{h1}\Delta z_{h2})(\Delta x_{h3}(\Delta y_{h1}\Delta y_{h2} + \right.\\
&\Delta z_{h1}\Delta z_{h2}) - \Delta x_{h2}(\Delta y_{h1}\Delta y_{h3} + \Delta z_{h1}\Delta z_{h3})) - \Delta x_{h2}l^2(\Delta x_{h2}\Delta x_{h3} + \\
&\left.\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3}) + \Delta x_{h3}l^4\right) + \Delta x_{h3}l^4 m_l^2)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(11,1) = \big(&\Delta x_{h1}\left(\Delta x_{h2}^2\Delta x_{h3}m_{h2}m_{h3}(\Delta x_{h1}\Delta y_{h3} - \Delta x_{h3}\Delta y_{h1}) + \right.\\
&\Delta x_{h2}m_{h2}\left(\Delta x_{h1}m_{h3}\left(\Delta x_{h3}^2\Delta y_{h2} + \Delta y_{h2}(\Delta y_{h3} - l)(\Delta y_{h3} + l) + \right.\right.\\
&\left.\Delta y_{h3}\Delta z_{h2}\Delta z_{h3}\right) - \Delta x_{h1}\Delta y_{h2}l^2 m_l + \Delta x_{h3}m_{h3}(-2\Delta y_{h1}\Delta z_{h2}\Delta z_{h3} + \\
&\Delta y_{h2}\Delta z_{h1}\Delta z_{h3} + \Delta y_{h3}\Delta z_{h1}\Delta z_{h2})) - l^2 m_l\left(\Delta y_{h3}m_{h3}(\Delta x_{h1}\Delta x_{h3} + \Delta z_{h1}\Delta z_{h3}) + \right.\\
&\Delta y_{h1}\left(\Delta y_{h2}^2 m_{h2} + \Delta y_{h3}^2 m_{h3} - l^2(m_{h2}+m_{h3})\right) + \Delta y_{h2}\Delta z_{h1}\Delta z_{h2}m_{h2}\big) + \\
&m_{h2}m_{h3}\left(-l^2\left(\Delta x_{h1}\Delta x_{h3}\Delta y_{h3} + \Delta y_{h1}\left(\Delta y_{h2}^2 + \Delta y_{h3}^2\right) + \Delta y_{h2}\Delta z_{h1}\Delta z_{h2} + \right.\right.\\
&\left.\Delta y_{h3}\Delta z_{h1}\Delta z_{h3}\right) + (\Delta y_{h2}\Delta y_{h3} + \Delta z_{h2}\Delta z_{h3})(\Delta x_{h1}\Delta x_{h3}\Delta y_{h2} + \\
&\Delta y_{h1}\Delta y_{h2}\Delta y_{h3} - \Delta y_{h1}\Delta z_{h2}\Delta z_{h3} + \Delta y_{h2}\Delta z_{h1}\Delta z_{h3} + \\
&\left.\Delta y_{h3}\Delta z_{h1}\Delta z_{h2}) + \Delta y_{h1}l^4\right) + \Delta y_{h1}l^4 m_l^2)\big)\big/\big(den\, m_{h1}m_{h2}m_{h3}m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(11,2) = \big((y_{h1}-y_l)\big(&\Delta x_{h2}^2\Delta x_{h3}m_{h2}m_{h3}(\Delta x_{h1}\Delta y_{h3}-\Delta x_{h3}\Delta y_{h1})+\\
&\Delta x_{h2}m_{h2}\big(\Delta x_{h1}m_{h3}\big(\Delta x_{h3}^2\Delta y_{h2}+\Delta y_{h2}(\Delta y_{h3}-l)(\Delta y_{h3}+l)+\\
&\Delta y_{h3}\Delta z_{h2}\Delta z_{h3}\big)-\Delta x_{h1}\Delta y_{h2}l^2m_l+\Delta x_{h3}m_{h3}(-2\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}+\\
&\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}+\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})\big)-l^2m_l\big(\Delta y_{h3}m_{h3}(\Delta x_{h1}\Delta x_{h3}+\Delta z_{h1}\Delta z_{h3})+\\
&\Delta y_{h1}\big(\Delta y_{h2}^2m_{h2}+\Delta y_{h3}^2m_{h3}-l^2(m_{h2}+m_{h3})\big)+\Delta y_{h2}\Delta z_{h1}\Delta z_{h2}m_{h2}\big)+\\
&m_{h2}m_{h3}\big(-l^2\big(\Delta x_{h1}\Delta x_{h3}\Delta y_{h3}+\Delta y_{h1}\big(\Delta y_{h2}^2+\Delta y_{h3}^2\big)+\Delta y_{h2}\Delta z_{h1}\Delta z_{h2}+\\
&\Delta y_{h3}\Delta z_{h1}\Delta z_{h3}\big)+(\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})(\Delta x_{h1}\Delta x_{h3}\Delta y_{h2}+\\
&\Delta y_{h1}\Delta y_{h2}\Delta y_{h3}-\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}+\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}+\\
&\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})+\Delta y_{h1}l^4\big)+\Delta y_{h1}l^4m_l^2\big)\big)/\big(den\,m_{h1}m_{h2}m_{h3}m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(11,3) = \big((z_{h1}-z_l)\big(&\Delta x_{h2}^2\Delta x_{h3}m_{h2}m_{h3}(\Delta x_{h1}\Delta y_{h3}-\Delta x_{h3}\Delta y_{h1})+\\
&\Delta x_{h2}m_{h2}\big(\Delta x_{h1}m_{h3}\big(\Delta x_{h3}^2\Delta y_{h2}+\Delta y_{h2}(\Delta y_{h3}-l)(\Delta y_{h3}+l)+\\
&\Delta y_{h3}\Delta z_{h2}\Delta z_{h3}\big)-\Delta x_{h1}\Delta y_{h2}l^2m_l+\Delta x_{h3}m_{h3}(-2\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}+\\
&\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}+\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})\big)-l^2m_l\big(\Delta y_{h3}m_{h3}(\Delta x_{h1}\Delta x_{h3}+\Delta z_{h1}\Delta z_{h3})+\\
&\Delta y_{h1}\big(\Delta y_{h2}^2m_{h2}+\Delta y_{h3}^2m_{h3}-l^2(m_{h2}+m_{h3})\big)+\Delta y_{h2}\Delta z_{h1}\Delta z_{h2}m_{h2}\big)+\\
&m_{h2}m_{h3}\big(-l^2\big(\Delta x_{h1}\Delta x_{h3}\Delta y_{h3}+\Delta y_{h1}\big(\Delta y_{h2}^2+\Delta y_{h3}^2\big)+\Delta y_{h2}\Delta z_{h1}\Delta z_{h2}+\\
&\Delta y_{h3}\Delta z_{h1}\Delta z_{h3}\big)+(\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})(\Delta x_{h1}\Delta x_{h3}\Delta y_{h2}+\\
&\Delta y_{h1}\Delta y_{h2}\Delta y_{h3}-\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}+\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}+\\
&\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})+\Delta y_{h1}l^4\big)+\Delta y_{h1}l^4m_l^2\big)\big)/\big(den\,m_{h1}m_{h2}m_{h3}m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(11,4) = \big(\Delta x_{h2}\big(&\Delta x_{h1}^2\Delta x_{h3}m_{h1}m_{h3}(\Delta x_{h2}\Delta y_{h3}-\Delta x_{h3}\Delta y_{h2})+\\
&\Delta x_{h1}m_{h1}\big(\Delta x_{h2}m_{h3}\big(\Delta x_{h3}^2\Delta y_{h1}+\Delta y_{h1}(\Delta y_{h3}-l)(\Delta y_{h3}+\\
&l)+\Delta y_{h3}\Delta z_{h1}\Delta z_{h3}\big)-\Delta x_{h2}\Delta y_{h1}l^2m_l+\\
&\Delta x_{h3}m_{h3}(\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}-2\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}+\\
&\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})\big)-l^2m_l\big(\Delta y_{h3}m_{h3}(\Delta x_{h2}\Delta x_{h3}+\Delta z_{h2}\Delta z_{h3})+\\
&\Delta y_{h1}^2\Delta y_{h2}m_{h1}+\Delta y_{h1}\Delta z_{h1}\Delta z_{h2}m_{h1}-\Delta y_{h2}\big(l^2(m_{h1}+m_{h3})-\Delta y_{h3}^2m_{h3}\big)\big)+\\
&m_{h1}m_{h3}\big(-l^2\big(\Delta y_{h3}(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})+\Delta y_{h1}^2\Delta y_{h2}+\\
&\Delta y_{h1}\Delta z_{h1}\Delta z_{h2}\big)+(\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}\Delta y_{h1}+\\
&\Delta y_{h1}\Delta y_{h2}\Delta y_{h3}+\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}-\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}+\\
&\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})+\Delta y_{h2}l^4\big)+\Delta y_{h2}l^4m_l^2\big)\big)/\big(den\,m_{h1}m_{h2}m_{h3}m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(11,5) = \big((y_{h2} - y_l)\big(&\Delta x_{h1}^2 \Delta x_{h3} m_{h1} m_{h3} (\Delta x_{h2} \Delta y_{h3} - \Delta x_{h3} \Delta y_{h2}) + \\
&\Delta x_{h1} m_{h1} \big(\Delta x_{h2} m_{h3} \big(\Delta x_{h3}^2 \Delta y_{h1} + \Delta y_{h1} (\Delta y_{h3} - l)(\Delta y_{h3} + \\
&l) + \Delta y_{h3} \Delta z_{h1} \Delta z_{h3}\big) - \Delta x_{h2} \Delta y_{h1} l^2 m_l + \\
&\Delta x_{h3} m_{h3} (\Delta y_{h1} \Delta z_{h2} \Delta z_{h3} - 2\Delta y_{h2} \Delta z_{h1} \Delta z_{h3} + \\
&\Delta y_{h3} \Delta z_{h1} \Delta z_{h2})\big) - l^2 m_l \big(\Delta y_{h3} m_{h3} (\Delta x_{h2} \Delta x_{h3} + \Delta z_{h2} \Delta z_{h3}) + \\
&\Delta y_{h1}^2 \Delta y_{h2} m_{h1} + \Delta y_{h1} \Delta z_{h1} \Delta z_{h2} m_{h1} - \Delta y_{h2} \big(l^2 (m_{h1} + m_{h3}) - \Delta y_{h3}^2 m_{h3}\big)\big) + \\
&m_{h1} m_{h3} \big(-l^2 \big(\Delta y_{h3} (\Delta x_{h2} \Delta x_{h3} + \Delta y_{h2} \Delta y_{h3} + \Delta z_{h2} \Delta z_{h3}) + \Delta y_{h1}^2 \Delta y_{h2} + \\
&\Delta y_{h1} \Delta z_{h1} \Delta z_{h2}\big) + (\Delta y_{h1} \Delta y_{h3} + \Delta z_{h1} \Delta z_{h3})(\Delta x_{h2} \Delta x_{h3} \Delta y_{h1} + \\
&\Delta y_{h1} \Delta y_{h2} \Delta y_{h3} + \Delta y_{h1} \Delta z_{h2} \Delta z_{h3} - \Delta y_{h2} \Delta z_{h1} \Delta z_{h3} + \\
&\Delta y_{h3} \Delta z_{h1} \Delta z_{h2}) + \Delta y_{h2} l^4\big) + \Delta y_{h2} l^4 m_l^2\big)\big) / \big(den\, m_{h1} m_{h2} m_{h3} m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(11,6) = \big((z_{h2} - z_l)\big(&\Delta x_{h1}^2 \Delta x_{h3} m_{h1} m_{h3} (\Delta x_{h2} \Delta y_{h3} - \Delta x_{h3} \Delta y_{h2}) + \\
&\Delta x_{h1} m_{h1} \big(\Delta x_{h2} m_{h3} \big(\Delta x_{h3}^2 \Delta y_{h1} + \Delta y_{h1} (\Delta y_{h3} - l)(\Delta y_{h3} + \\
&l) + \Delta y_{h3} \Delta z_{h1} \Delta z_{h3}\big) - \Delta x_{h2} \Delta y_{h1} l^2 m_l + \\
&\Delta x_{h3} m_{h3} (\Delta y_{h1} \Delta z_{h2} \Delta z_{h3} - 2\Delta y_{h2} \Delta z_{h1} \Delta z_{h3} + \\
&\Delta y_{h3} \Delta z_{h1} \Delta z_{h2})\big) - l^2 m_l \big(\Delta y_{h3} m_{h3} (\Delta x_{h2} \Delta x_{h3} + \Delta z_{h2} \Delta z_{h3}) + \\
&\Delta y_{h1}^2 \Delta y_{h2} m_{h1} + \Delta y_{h1} \Delta z_{h1} \Delta z_{h2} m_{h1} - \Delta y_{h2} \big(l^2 (m_{h1} + m_{h3}) - \Delta y_{h3}^2 m_{h3}\big)\big) + \\
&m_{h1} m_{h3} \big(-l^2 \big(\Delta y_{h3} (\Delta x_{h2} \Delta x_{h3} + \Delta y_{h2} \Delta y_{h3} + \Delta z_{h2} \Delta z_{h3}) + \Delta y_{h1}^2 \Delta y_{h2} + \\
&\Delta y_{h1} \Delta z_{h1} \Delta z_{h2}\big) + (\Delta y_{h1} \Delta y_{h3} + \Delta z_{h1} \Delta z_{h3})(\Delta x_{h2} \Delta x_{h3} \Delta y_{h1} + \\
&\Delta y_{h1} \Delta y_{h2} \Delta y_{h3} + \Delta y_{h1} \Delta z_{h2} \Delta z_{h3} - \Delta y_{h2} \Delta z_{h1} \Delta z_{h3} + \\
&\Delta y_{h3} \Delta z_{h1} \Delta z_{h2}) + \Delta y_{h2} l^4\big) + \Delta y_{h2} l^4 m_l^2\big)\big) / \big(den\, m_{h1} m_{h2} m_{h3} m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(11,7) = \big(\Delta x_{h3}\big(&\Delta x_{h1}^2 \Delta x_{h2} m_{h1} m_{h2} (\Delta x_{h3} \Delta y_{h2} - \Delta x_{h2} \Delta y_{h3}) + \\
&\Delta x_{h1} m_{h1} \big(m_{h2} \big(\Delta x_{h2}^2 \Delta x_{h3} \Delta y_{h1} + \Delta x_{h2} (\Delta y_{h1} \Delta z_{h2} \Delta z_{h3} + \\
&\Delta y_{h2} \Delta z_{h1} \Delta z_{h3} - 2\Delta y_{h3} \Delta z_{h1} \Delta z_{h2}) + \Delta x_{h3} (\Delta y_{h1} (\Delta y_{h2} - l)(\Delta y_{h2} + l) + \\
&\Delta y_{h2} \Delta z_{h1} \Delta z_{h2})\big) - \Delta x_{h3} \Delta y_{h1} l^2 m_l\big) - l^2 m_l \big(\Delta y_{h2} m_{h2} (\Delta x_{h2} \Delta x_{h3} + \\
&\Delta z_{h2} \Delta z_{h3}) + \Delta y_{h1}^2 \Delta y_{h3} m_{h1} + \Delta y_{h1} \Delta z_{h1} \Delta z_{h3} m_{h1} - \Delta y_{h3} \big(l^2 (m_{h1} + \\
&m_{h2}) - \Delta y_{h2}^2 m_{h2}\big)\big) + m_{h1} m_{h2} \big(-l^2 (\Delta y_{h2} (\Delta x_{h2} \Delta x_{h3} + \Delta y_{h2} \Delta y_{h3} + \Delta z_{h2} \Delta z_{h3}) + \\
&\Delta y_{h1} (\Delta y_{h1} \Delta y_{h3} + \Delta z_{h1} \Delta z_{h3})) + (\Delta y_{h1} \Delta y_{h2} + \Delta z_{h1} \Delta z_{h2})(\Delta x_{h2} \Delta x_{h3} \Delta y_{h1} + \\
&\Delta y_{h1} \Delta y_{h2} \Delta y_{h3} + \Delta y_{h1} \Delta z_{h2} \Delta z_{h3} + \Delta y_{h2} \Delta z_{h1} \Delta z_{h3} - \Delta y_{h3} \Delta z_{h1} \Delta z_{h2}) + \\
&\Delta y_{h3} l^4\big) + \Delta y_{h3} l^4 m_l^2\big)\big) / \big(den\, m_{h1} m_{h2} m_{h3} m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(11,8) = &\big((y_{h3}-y_l)\left(\Delta x_{h1}^2\Delta x_{h2}m_{h1}m_{h2}(\Delta x_{h3}\Delta y_{h2}-\Delta x_{h2}\Delta y_{h3})+\right.\\
&\Delta x_{h1}m_{h1}\left(m_{h2}\left(\Delta x_{h2}^2\Delta x_{h3}\Delta y_{h1}+\Delta x_{h2}(\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}+\right.\right.\\
&\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}-2\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})+\Delta x_{h3}(\Delta y_{h1}(\Delta y_{h2}-l)(\Delta y_{h2}+l)+\\
&\left.\left.\Delta y_{h2}\Delta z_{h1}\Delta z_{h2})\right)-\Delta x_{h3}\Delta y_{h1}l^2m_l\right)-l^2m_l\left(\Delta y_{h2}m_{h2}(\Delta x_{h2}\Delta x_{h3}+\right.\\
&\Delta z_{h2}\Delta z_{h3})+\Delta y_{h1}^2\Delta y_{h3}m_{h1}+\Delta y_{h1}\Delta z_{h1}\Delta z_{h3}m_{h1}-\Delta y_{h3}\left(l^2(m_{h1}+\\
&\left.m_{h2})-\Delta y_{h2}^2m_{h2}\right)\right)+m_{h1}m_{h2}\left(-l^2(\Delta y_{h2}(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})+\right.\\
&\Delta y_{h1}(\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3}))+(\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}\Delta y_{h1}+\\
&\Delta y_{h1}\Delta y_{h2}\Delta y_{h3}+\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}+\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}-\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})+\\
&\left.\Delta y_{h3}l^4\right)+\Delta y_{h3}l^4m_l^2)\big)/\left(den\,m_{h1}m_{h2}m_{h3}m_l^3\right)
\end{aligned}
$$

$$
\begin{aligned}
C(11,9) = &\big((z_{h3}-z_l)\left(\Delta x_{h1}^2\Delta x_{h2}m_{h1}m_{h2}(\Delta x_{h3}\Delta y_{h2}-\Delta x_{h2}\Delta y_{h3})+\right.\\
&\Delta x_{h1}m_{h1}\left(m_{h2}\left(\Delta x_{h2}^2\Delta x_{h3}\Delta y_{h1}+\Delta x_{h2}(\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}+\right.\right.\\
&\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}-2\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})+\Delta x_{h3}(\Delta y_{h1}(\Delta y_{h2}-l)(\Delta y_{h2}+l)+\\
&\left.\left.\Delta y_{h2}\Delta z_{h1}\Delta z_{h2})\right)-\Delta x_{h3}\Delta y_{h1}l^2m_l\right)-l^2m_l\left(\Delta y_{h2}m_{h2}(\Delta x_{h2}\Delta x_{h3}+\right.\\
&\Delta z_{h2}\Delta z_{h3})+\Delta y_{h1}^2\Delta y_{h3}m_{h1}+\Delta y_{h1}\Delta z_{h1}\Delta z_{h3}m_{h1}-\Delta y_{h3}\left(l^2(m_{h1}+\\
&\left.m_{h2})-\Delta y_{h2}^2m_{h2}\right)\right)+m_{h1}m_{h2}\left(-l^2(\Delta y_{h2}(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})+\right.\\
&\Delta y_{h1}(\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3}))+(\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}\Delta y_{h1}+\\
&\Delta y_{h1}\Delta y_{h2}\Delta y_{h3}+\Delta y_{h1}\Delta z_{h2}\Delta z_{h3}+\Delta y_{h2}\Delta z_{h1}\Delta z_{h3}-\Delta y_{h3}\Delta z_{h1}\Delta z_{h2})+\\
&\left.\Delta y_{h3}l^4\right)+\Delta y_{h3}l^4m_l^2)\big)/\left(den\,m_{h1}m_{h2}m_{h3}m_l^3\right)
\end{aligned}
$$

$$
\begin{aligned}
C(12,1) = &\big(\Delta x_{h1}\left(\Delta x_{h2}^2\Delta x_{h3}m_{h2}m_{h3}(\Delta x_{h1}\Delta z_{h3}-\Delta x_{h3}\Delta z_{h1})+\right.\\
&\Delta x_{h2}m_{h2}\left(\Delta x_{h1}\Delta x_{h3}^2\Delta z_{h2}m_{h3}+\Delta x_{h1}\left(\Delta y_{h2}\Delta y_{h3}\Delta z_{h3}m_{h3}+\right.\right.\\
&\left.\left.\Delta z_{h2}\left(\Delta z_{h3}^2m_{h3}-l^2(m_{h3}+m_l)\right)\right)+\Delta x_{h3}m_{h3}(\Delta y_{h1}\Delta y_{h2}\Delta z_{h3}+\right.\\
&\Delta y_{h1}\Delta y_{h3}\Delta z_{h2}-2\Delta y_{h2}\Delta y_{h3}\Delta z_{h1})\big)+\Delta y_{h2}\Delta z_{h2}m_{h2}\left(\Delta x_{h1}\Delta x_{h3}\Delta y_{h3}m_{h3}+\right.\\
&\Delta y_{h1}\left(\Delta y_{h3}^2m_{h3}+\Delta z_{h3}^2m_{h3}-l^2(m_{h3}+m_l)\right)\big)+\\
&\left(\Delta z_{h2}^2m_{h2}-l^2(m_{h2}+m_l)\right)\left(m_{h3}(\Delta x_{h1}\Delta x_{h3}\Delta z_{h3}+\right.\\
&\Delta y_{h1}\Delta y_{h3}\Delta z_{h3}+\Delta z_{h1}(\Delta z_{h3}-l)(\Delta z_{h3}+l))-\Delta z_{h1}l^2m_l\big)+\\
&\left.\Delta y_{h2}^2\Delta y_{h3}m_{h2}m_{h3}(\Delta y_{h1}\Delta z_{h3}-\Delta y_{h3}\Delta z_{h1}))\right)/\left(den\,m_{h1}m_{h2}m_{h3}m_l^3\right)
\end{aligned}
$$

$$
\begin{aligned}
C(12,2) = -&\big((y_{h1}-y_l)\left(\Delta x_{h2}^2\Delta x_{h3}m_{h2}m_{h3}(\Delta x_{h3}\Delta z_{h1}-\Delta x_{h1}\Delta z_{h3})+\right.\\
&\Delta x_{h2}m_{h2}\left(\Delta x_{h1}\Delta z_{h2}l^2m_l-m_{h3}\left(\Delta x_{h1}\Delta x_{h3}^2\Delta z_{h2}+\right.\right.\\
&\Delta x_{h1}(\Delta y_{h2}\Delta y_{h3}\Delta z_{h3}+\Delta z_{h2}(\Delta z_{h3}-l)(\Delta z_{h3}+l))+\\
&\left.\left.\Delta x_{h3}(\Delta y_{h1}\Delta y_{h2}\Delta z_{h3}+\Delta y_{h1}\Delta y_{h3}\Delta z_{h2}-2\Delta y_{h2}\Delta y_{h3}\Delta z_{h1}))\right)+\right.\\
&\Delta y_{h2}\Delta z_{h2}m_{h2}\left(\Delta y_{h1}l^2m_l-m_{h3}\left(\Delta x_{h1}\Delta x_{h3}\Delta y_{h3}+\Delta y_{h1}\left(\Delta y_{h3}^2+\right.\right.\right.\\
&\left.\left.\left.\Delta z_{h3}^2-l^2\right)\right)\right)+\left(\Delta z_{h2}^2m_{h2}-l^2(m_{h2}+m_l)\right)\left(\Delta z_{h1}l^2m_l-m_{h3}(\Delta x_{h1}\Delta x_{h3}\Delta z_{h3}+\right.\\
&\Delta y_{h1}\Delta y_{h3}\Delta z_{h3}+\Delta z_{h1}(\Delta z_{h3}-l)(\Delta z_{h3}+l))\big)+\\
&\left.\Delta y_{h2}^2\Delta y_{h3}m_{h2}m_{h3}(\Delta y_{h3}\Delta z_{h1}-\Delta y_{h1}\Delta z_{h3}))\right)/\left(den\,m_{h1}m_{h2}m_{h3}m_l^3\right)
\end{aligned}
$$

$$
\begin{aligned}
C(12,3) = &-\big((z_{h1}-z_l)\left(\Delta x_{h2}^2\Delta x_{h3}m_{h2}m_{h3}(\Delta x_{h3}\Delta z_{h1}-\Delta x_{h1}\Delta z_{h3})+\right.\\
&\Delta x_{h2}m_{h2}\left(\Delta x_{h1}\Delta z_{h2}l^2m_l-m_{h3}\left(\Delta x_{h1}\Delta x_{h3}^2\Delta z_{h2}+\right.\right.\\
&\Delta x_{h1}(\Delta y_{h2}\Delta y_{h3}\Delta z_{h3}+\Delta z_{h2}(\Delta z_{h3}-l)(\Delta z_{h3}+l))+\\
&\left.\left.\Delta x_{h3}(\Delta y_{h1}\Delta y_{h2}\Delta z_{h3}+\Delta y_{h1}\Delta y_{h3}\Delta z_{h2}-2\Delta y_{h2}\Delta y_{h3}\Delta z_{h1})\right)\right)+\\
&\Delta y_{h2}\Delta z_{h2}m_{h2}\left(\Delta y_{h1}l^2m_l-m_{h3}\left(\Delta x_{h1}\Delta x_{h3}\Delta y_{h3}+\Delta y_{h1}\left(\Delta y_{h3}^2+\right.\right.\right.\\
&\left.\left.\left.\Delta z_{h3}^2-l^2\right)\right)\right)+\left(\Delta z_{h2}^2m_{h2}-l^2(m_{h2}+m_l)\right)\left(\Delta z_{h1}l^2m_l-m_{h3}(\Delta x_{h1}\Delta x_{h3}\Delta z_{h3}+\right.\\
&\Delta y_{h1}\Delta y_{h3}\Delta z_{h3}+\Delta z_{h1}(\Delta z_{h3}-l)(\Delta z_{h3}+l))+\\
&\left.\Delta y_{h2}^2\Delta y_{h3}m_{h2}m_{h3}(\Delta y_{h3}\Delta z_{h1}-\Delta y_{h1}\Delta z_{h3}))\right)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^3\right)
\end{aligned}
$$

$$
\begin{aligned}
C(12,4) = &\left(\Delta x_{h2}\left(\Delta x_{h1}^2\Delta x_{h3}m_{h1}m_{h3}(\Delta x_{h2}\Delta z_{h3}-\Delta x_{h3}\Delta z_{h2})+\right.\right.\\
&\Delta x_{h1}m_{h1}\left(\Delta x_{h2}m_{h3}\left(\Delta z_{h1}\left(\Delta x_{h3}^2+\Delta z_{h3}^2-l^2\right)+\right.\right.\\
&\left.\left.\Delta y_{h1}\Delta y_{h3}\Delta z_{h3}\right)-\Delta x_{h2}\Delta z_{h1}l^2m_l+\right.\\
&\Delta x_{h3}m_{h3}(\Delta y_{h1}\Delta y_{h2}\Delta z_{h3}-2\Delta y_{h1}\Delta y_{h3}\Delta z_{h2}+\\
&\left.\Delta y_{h2}\Delta y_{h3}\Delta z_{h1})\right)-l^2m_l\left(\Delta x_{h2}\Delta x_{h3}\Delta z_{h3}m_{h3}+\Delta y_{h1}\Delta y_{h2}\Delta z_{h1}m_{h1}+\right.\\
&\left.\Delta y_{h2}\Delta y_{h3}\Delta z_{h3}m_{h3}+\Delta z_{h2}\left(\Delta z_{h1}^2m_{h1}+\Delta z_{h3}^2m_{h3}-l^2(m_{h1}+m_{h3})\right)\right)+\\
&m_{h1}m_{h3}\left(-l^2\left(\Delta x_{h2}\Delta x_{h3}\Delta z_{h3}+\Delta y_{h1}\Delta y_{h2}\Delta z_{h1}+\Delta y_{h2}\Delta y_{h3}\Delta z_{h3}+\right.\right.\\
&\Delta z_{h2}\left(\Delta z_{h1}^2+\Delta z_{h3}^2\right)\Big)+(\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}\Delta z_{h1}+\\
&\Delta y_{h1}\Delta y_{h2}\Delta z_{h3}-\Delta y_{h1}\Delta y_{h3}\Delta z_{h2}+\Delta y_{h2}\Delta y_{h3}\Delta z_{h1}+\\
&\left.\left.\Delta z_{h1}\Delta z_{h2}\Delta z_{h3})+\Delta z_{h2}l^4\right)+\Delta z_{h2}l^4m_l^2\right)\Big)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^3\right)
\end{aligned}
$$

$$
\begin{aligned}
C(12,5) = &\left((y_{h2}-y_l)\left(\Delta x_{h1}^2\Delta x_{h3}m_{h1}m_{h3}(\Delta x_{h2}\Delta z_{h3}-\Delta x_{h3}\Delta z_{h2})+\right.\right.\\
&\Delta x_{h1}m_{h1}\left(\Delta x_{h2}m_{h3}\left(\Delta z_{h1}\left(\Delta x_{h3}^2+\Delta z_{h3}^2-l^2\right)+\right.\right.\\
&\left.\left.\Delta y_{h1}\Delta y_{h3}\Delta z_{h3}\right)-\Delta x_{h2}\Delta z_{h1}l^2m_l+\right.\\
&\Delta x_{h3}m_{h3}(\Delta y_{h1}\Delta y_{h2}\Delta z_{h3}-2\Delta y_{h1}\Delta y_{h3}\Delta z_{h2}+\\
&\left.\Delta y_{h2}\Delta y_{h3}\Delta z_{h1})\right)-l^2m_l\left(\Delta x_{h2}\Delta x_{h3}\Delta z_{h3}m_{h3}+\Delta y_{h1}\Delta y_{h2}\Delta z_{h1}m_{h1}+\right.\\
&\left.\Delta y_{h2}\Delta y_{h3}\Delta z_{h3}m_{h3}+\Delta z_{h2}\left(\Delta z_{h1}^2m_{h1}+\Delta z_{h3}^2m_{h3}-l^2(m_{h1}+m_{h3})\right)\right)+\\
&m_{h1}m_{h3}\left(-l^2\left(\Delta x_{h2}\Delta x_{h3}\Delta z_{h3}+\Delta y_{h1}\Delta y_{h2}\Delta z_{h1}+\Delta y_{h2}\Delta y_{h3}\Delta z_{h3}+\right.\right.\\
&\Delta z_{h2}\left(\Delta z_{h1}^2+\Delta z_{h3}^2\right)\Big)+(\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}\Delta z_{h1}+\\
&\Delta y_{h1}\Delta y_{h2}\Delta z_{h3}-\Delta y_{h1}\Delta y_{h3}\Delta z_{h2}+\Delta y_{h2}\Delta y_{h3}\Delta z_{h1}+\\
&\left.\left.\Delta z_{h1}\Delta z_{h2}\Delta z_{h3})+\Delta z_{h2}l^4\right)+\Delta z_{h2}l^4m_l^2\right)\Big)/\left(den\, m_{h1}m_{h2}m_{h3}m_l^3\right)
\end{aligned}
$$

$$
\begin{aligned}
C(12,6) = \big((z_{h2} - z_l)\,\big(&\Delta x_{h1}^2 \Delta x_{h3} m_{h1} m_{h3} (\Delta x_{h2} \Delta z_{h3} - \Delta x_{h3} \Delta z_{h2}) + \\
&\Delta x_{h1} m_{h1} \big(\Delta x_{h2} m_{h3} \big(\Delta z_{h1} \big(\Delta x_{h3}^2 + \Delta z_{h3}^2 - l^2\big) + \\
&\Delta y_{h1} \Delta y_{h3} \Delta z_{h3}\big) - \Delta x_{h2} \Delta z_{h1} l^2 m_l + \\
&\Delta x_{h3} m_{h3} (\Delta y_{h1} \Delta y_{h2} \Delta z_{h3} - 2\Delta y_{h1} \Delta y_{h3} \Delta z_{h2} + \\
&\Delta y_{h2} \Delta y_{h3} \Delta z_{h1})\big) - l^2 m_l \big(\Delta x_{h2} \Delta x_{h3} \Delta z_{h3} m_{h3} + \Delta y_{h1} \Delta y_{h2} \Delta z_{h1} m_{h1} + \\
&\Delta y_{h2} \Delta y_{h3} \Delta z_{h3} m_{h3} + \Delta z_{h2} \big(\Delta z_{h1}^2 m_{h1} + \Delta z_{h3}^2 m_{h3} - l^2 (m_{h1} + m_{h3})\big)\big) + \\
&m_{h1} m_{h3} \big(-l^2 \big(\Delta x_{h2} \Delta x_{h3} \Delta z_{h3} + \Delta y_{h1} \Delta y_{h2} \Delta z_{h1} + \Delta y_{h2} \Delta y_{h3} \Delta z_{h3} + \\
&\Delta z_{h2} \big(\Delta z_{h1}^2 + \Delta z_{h3}^2\big)\big) + (\Delta y_{h1} \Delta y_{h3} + \Delta z_{h1} \Delta z_{h3})(\Delta x_{h2} \Delta x_{h3} \Delta z_{h1} + \\
&\Delta y_{h1} \Delta y_{h2} \Delta z_{h3} - \Delta y_{h1} \Delta y_{h3} \Delta z_{h2} + \Delta y_{h2} \Delta y_{h3} \Delta z_{h1} + \\
&\Delta z_{h1} \Delta z_{h2} \Delta z_{h3}) + \Delta z_{h2} l^4\big) + \Delta z_{h2} l^4 m_l^2\big)\big) / \big(den\, m_{h1} m_{h2} m_{h3} m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(12,7) = \big(\Delta x_{h3}\,\big(&\Delta x_{h1}^2 \Delta x_{h2} m_{h1} m_{h2} (\Delta x_{h3} \Delta z_{h2} - \Delta x_{h2} \Delta z_{h3}) + \\
&\Delta x_{h1} m_{h1} \big(m_{h2} \big(\Delta x_{h2}^2 \Delta x_{h3} \Delta z_{h1} + \Delta x_{h2} (-2\Delta y_{h1} \Delta y_{h2} \Delta z_{h3} + \\
&\Delta y_{h1} \Delta y_{h3} \Delta z_{h2} + \Delta y_{h2} \Delta y_{h3} \Delta z_{h1}) + \Delta x_{h3} (\Delta y_{h1} \Delta y_{h2} \Delta z_{h2} + \\
&\Delta z_{h1} (\Delta z_{h2} - l)(\Delta z_{h2} + l))\big) - \Delta x_{h3} \Delta z_{h1} l^2 m_l\big) - l^2 m_l \big(\Delta z_{h2} m_{h2} (\Delta x_{h2} \Delta x_{h3} + \\
&\Delta y_{h2} \Delta y_{h3}) + \Delta y_{h1} \Delta y_{h3} \Delta z_{h1} m_{h1} + \Delta z_{h3} \big(\Delta z_{h1}^2 m_{h1} + \\
&\Delta z_{h2}^2 m_{h2} - l^2 (m_{h1} + m_{h2})\big)\big) + m_{h1} m_{h2} \big(-l^2 \big(\Delta x_{h2} \Delta x_{h3} \Delta z_{h2} + \\
&\Delta y_{h1} \Delta y_{h3} \Delta z_{h1} + \Delta y_{h2} \Delta y_{h3} \Delta z_{h2} + \Delta z_{h3} \big(\Delta z_{h1}^2 + \Delta z_{h2}^2\big)\big) + \\
&(\Delta y_{h1} \Delta y_{h2} + \Delta z_{h1} \Delta z_{h2})(\Delta x_{h2} \Delta x_{h3} \Delta z_{h1} - \Delta y_{h1} \Delta y_{h2} \Delta z_{h3} + \\
&\Delta y_{h1} \Delta y_{h3} \Delta z_{h2} + \Delta y_{h2} \Delta y_{h3} \Delta z_{h1} + \Delta z_{h1} \Delta z_{h2} \Delta z_{h3}) + \\
&\Delta z_{h3} l^4\big) + \Delta z_{h3} l^4 m_l^2\big)\big) / \big(den\, m_{h1} m_{h2} m_{h3} m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(12,8) = -\big((y_{h3} - y_l)\,\big(&\Delta x_{h1}^2 \Delta x_{h2} m_{h1} m_{h2} (\Delta x_{h2} \Delta z_{h3} - \Delta x_{h3} \Delta z_{h2}) + \\
&\Delta x_{h1} m_{h1} \big(\Delta x_{h3} \Delta z_{h1} l^2 m_l - m_{h2} \big(\Delta x_{h2}^2 \Delta x_{h3} \Delta z_{h1} + \Delta x_{h2} (-2\Delta y_{h1} \Delta y_{h2} \Delta z_{h3} + \\
&\Delta y_{h1} \Delta y_{h3} \Delta z_{h2} + \Delta y_{h2} \Delta y_{h3} \Delta z_{h1}) + \Delta x_{h3} (\Delta y_{h1} \Delta y_{h2} \Delta z_{h2} + \\
&\Delta z_{h1} (\Delta z_{h2} - l)(\Delta z_{h2} + l))\big)\big) + l^2 m_l \big(\Delta z_{h2} m_{h2} (\Delta x_{h2} \Delta x_{h3} + \\
&\Delta y_{h2} \Delta y_{h3}) + \Delta y_{h1} \Delta y_{h3} \Delta z_{h1} m_{h1} + \Delta z_{h3} \big(\Delta z_{h1}^2 m_{h1} + \\
&\Delta z_{h2}^2 m_{h2} - l^2 (m_{h1} + m_{h2})\big)\big) - m_{h1} m_{h2} \big(-l^2 \big(\Delta x_{h2} \Delta x_{h3} \Delta z_{h2} + \\
&\Delta y_{h1} \Delta y_{h3} \Delta z_{h1} + \Delta y_{h2} \Delta y_{h3} \Delta z_{h2} + \Delta z_{h3} \big(\Delta z_{h1}^2 + \Delta z_{h2}^2\big)\big) + \\
&(\Delta y_{h1} \Delta y_{h2} + \Delta z_{h1} \Delta z_{h2})(\Delta x_{h2} \Delta x_{h3} \Delta z_{h1} - \Delta y_{h1} \Delta y_{h2} \Delta z_{h3} + \\
&\Delta y_{h1} \Delta y_{h3} \Delta z_{h2} + \Delta y_{h2} \Delta y_{h3} \Delta z_{h1} + \Delta z_{h1} \Delta z_{h2} \Delta z_{h3}) + \\
&\Delta z_{h3} l^4\big) - \Delta z_{h3} l^4 m_l^2\big)\big) / \big(den\, m_{h1} m_{h2} m_{h3} m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
C(12,9) = &-\big((z_{h3}-z_l)\left(\Delta x_{h1}^2\Delta x_{h2}m_{h1}m_{h2}(\Delta x_{h2}\Delta z_{h3}-\Delta x_{h3}\Delta z_{h2})+\right.\\
&\Delta x_{h1}m_{h1}\left(\Delta x_{h3}\Delta z_{h1}l^2m_l-m_{h2}\left(\Delta x_{h2}^2\Delta x_{h3}\Delta z_{h1}+\Delta x_{h2}(-2\Delta y_{h1}\Delta y_{h2}\Delta z_{h3}+\right.\right.\\
&\Delta y_{h1}\Delta y_{h3}\Delta z_{h2}+\Delta y_{h2}\Delta y_{h3}\Delta z_{h1})+\Delta x_{h3}(\Delta y_{h1}\Delta y_{h2}\Delta z_{h2}+\\
&\left.\left.\Delta z_{h1}(\Delta z_{h2}-l)(\Delta z_{h2}+l))\right)\right)+l^2m_l\left(\Delta z_{h2}m_{h2}(\Delta x_{h2}\Delta x_{h3}+\right.\\
&\Delta y_{h2}\Delta y_{h3})+\Delta y_{h1}\Delta y_{h3}\Delta z_{h1}m_{h1}+\Delta z_{h3}\left(\Delta z_{h1}^2m_{h1}+\right.\\
&\left.\left.\Delta z_{h2}^2m_{h2}-l^2(m_{h1}+m_{h2})\right)\right)-m_{h1}m_{h2}\left(-l^2\left(\Delta x_{h2}\Delta x_{h3}\Delta z_{h2}+\right.\right.\\
&\Delta y_{h1}\Delta y_{h3}\Delta z_{h1}+\Delta y_{h2}\Delta y_{h3}\Delta z_{h2}+\Delta z_{h3}\left(\Delta z_{h1}^2+\Delta z_{h2}^2\right)\right)+\\
&(\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}\Delta z_{h1}-\Delta y_{h1}\Delta y_{h2}\Delta z_{h3}+\\
&\Delta y_{h1}\Delta y_{h3}\Delta z_{h2}+\Delta y_{h2}\Delta y_{h3}\Delta z_{h1}+\Delta z_{h1}\Delta z_{h2}\Delta z_{h3})+\\
&\left.\Delta z_{h3}l^4\big)-\Delta z_{h3}l^4m_l^2\big)\big)/\big(den\,m_{h1}m_{h2}m_{h3}m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
d(1) = &\ddot{x}_{h1}-\big(\Delta x_{h1}\left(-\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\right)\left((\Delta x_{h1}\Delta x_{h2}+\right.\right.\\
&\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+\\
&m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\big)-\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+\right.\\
&\left.(\dot{z}_{h2}-\dot{z}_l)^2\right)\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)+\\
&\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\left(-\left(\left(l^4(m_{h2}+m_l)(m_{h3}+\right.\right.\right.\\
&\left.\left.\left.m_l)\right)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\right)\right)\big)\big)/\big(den\,m_{h1}m_l^2\big)
\end{aligned}
$$

$$
\begin{aligned}
d(2) = &\ddot{y}_{h1}-\big(\Delta y_{h1}\left(-\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\right)\left((\Delta x_{h1}\Delta x_{h2}+\right.\right.\\
&\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+\\
&m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\big)-\left((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+\right.\\
&\left.(\dot{z}_{h2}-\dot{z}_l)^2\right)\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\right.\\
&\left.\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)+\\
&\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\right)\left(-\left(\left(l^4(m_{h2}+m_l)(m_{h3}+\right.\right.\right.\\
&\left.\left.\left.m_l)\right)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\right)\right)\big)\big)/\big(den\,m_{h1}m_l^2\big)
\end{aligned}
$$

$$
\begin{aligned}
d(3) = &-\big(\Delta z_{h1}\left(-\left((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\right)\left((\Delta x_{h1}\Delta x_{h2}+\right.\right.\\
&\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+\\
&m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\big)-\left((\dot{x}_{h2}-\dot{x}_l)^2+\right.\\
&\left.(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\right)\left((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\right.\\
&\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\right.\\
&\left.\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)+\left((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+\right.\\
&\left.(\dot{z}_{h1}-\dot{z}_l)^2\right)\left(-\left(\left(l^4(m_{h2}+m_l)(m_{h3}+m_l)\right)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\right.\right.\\
&\left.\left.\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\right)\right)\big)\big)/\big(den\,m_{h1}m_l^2\big)+G+\ddot{z}_{h1}
\end{aligned}
$$

$$
\begin{aligned}
d(4) = {} & \ddot{x}_{h2} - \big(\Delta x_{h2}\big(-\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\big((\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+\\
& m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)+\big((\dot{x}_{h1}-\dot{x}_l)^2+\\
& (\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big(-\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\\
& \Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+\\
& m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)\big)-\big((\dot{x}_{h2}-\dot{x}_l)^2+\\
& (\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\big(\big(l^4(m_{h1}+m_l)(m_{h3}+\\
& m_l)\big)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\big)\big)\big)/\big(den\, m_{h2}m_l^2\big)
\end{aligned}
$$

$$
\begin{aligned}
d(5) = {} & \ddot{y}_{h2} - \big(\Delta y_{h2}\big(-\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\big((\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+\\
& m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)+\big((\dot{x}_{h1}-\dot{x}_l)^2+\\
& (\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big(-\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\\
& \Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+\\
& m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)\big)-\big((\dot{x}_{h2}-\dot{x}_l)^2+\\
& (\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\big(\big(l^4(m_{h1}+m_l)(m_{h3}+\\
& m_l)\big)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\big)\big)\big)/\big(den\, m_{h2}m_l^2\big)
\end{aligned}
$$

$$
\begin{aligned}
d(6) = {} & -\big(\Delta z_{h2}\big(-\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\big((\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+\\
& m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)+\big((\dot{x}_{h1}-\dot{x}_l)^2+\\
& (\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big(-\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\\
& \Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)\big)-\big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+\\
& (\dot{z}_{h2}-\dot{z}_l)^2\big)\big(\big(l^4(m_{h1}+m_l)(m_{h3}+m_l)\big)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\\
& \Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\big)\big)\big)/\big(den\, m_{h2}m_l^2\big)+G+\ddot{z}_{h2}
\end{aligned}
$$

$$
\begin{aligned}
d(7) = {} & \ddot{x}_{h3} - \big(\Delta x_{h3}\big(-\big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\big((\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+\\
& m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)+\big((\dot{x}_{h1}-\dot{x}_l)^2+\\
& (\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big(-\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\
& \Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+\\
& m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\big)\big)-\big((\dot{x}_{h3}-\dot{x}_l)^2+\\
& (\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\big(\big(l^4(m_{h1}+m_l)(m_{h2}+\\
& m_l)\big)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\big)\big)\big)/\big(den\, m_{h3}m_l^2\big)
\end{aligned}
$$

$$
\begin{aligned}
d(8) = {} & \ddot{y}_{h3} - \big(\Delta y_{h3}\big(-\big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\big((\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+\\
& m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)+\big((\dot{x}_{h1}-\dot{x}_l)^2+\\
& (\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big(-\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\
& \Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+\\
& m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\big)\big)-\big((\dot{x}_{h3}-\dot{x}_l)^2+\\
& (\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\big(\big(l^4(m_{h1}+m_l)(m_{h2}+\\
& m_l)\big)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\big)\big)\big)/\big(den\, m_{h3}m_l^2\big)
\end{aligned}
$$

$$
\begin{aligned}
d(9) = {} & -\big(\Delta z_{h3}\big(-\big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\big((\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+\\
& m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)+\big((\dot{x}_{h1}-\dot{x}_l)^2+\\
& (\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big(-\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\
& \Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\\
& \Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\big)\big)-\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+\\
& (\dot{z}_{h3}-\dot{z}_l)^2\big)\big(\big(l^4(m_{h1}+m_l)(m_{h2}+m_l)\big)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\big)\big)\big)/\big(den\, m_{h3}m_l^2\big)+G+\ddot{z}_{h3}
\end{aligned}
$$

$$
\begin{aligned}
d(10) = {} & \ddot{x}_l-\big(\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\big(\Delta x_{h2}\big((\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+\\
& m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)+\Delta x_{h1}\big((\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+\\
& m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\big)+\Delta x_{h3}\big(\big(l^4(m_{h1}+\\
& m_l)(m_{h2}+m_l)\big)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\big)\big)+\\
& \big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\big(\Delta x_{h3}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\
& \Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\\
& \Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\big)+\Delta x_{h1}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\\
& \Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+\\
& m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)+\Delta x_{h2}\big(\big(l^4(m_{h1}+\\
& m_l)(m_{h3}+m_l)\big)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\big)\big)+\\
& \big((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\big(\Delta x_{h3}\big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\
& \Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\\
& \Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\big)+\Delta x_{h2}\big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\\
& \Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\\
& \Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\big)+\Delta x_{h1}\big(\big(l^4(m_{h2}+m_l)(m_{h3}+\\
& m_l)\big)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\big)\big)\big)/\big(den\, m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
d(11) = \ddot{y}_l - \Big(\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\Big(\Delta y_{h2}\Big((\Delta x_{h1}\Delta x_{h2}+\\
\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+\\
m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\Big)+\Delta y_{h1}\Big((\Delta x_{h1}\Delta x_{h2}+\\
\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+\\
m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\Big)+\Delta y_{h3}\Big(\big(l^4(m_{h1}+\\
m_l)(m_{h2}+m_l)\big)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\big)\Big)+\\
\big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\Big(\Delta y_{h3}\Big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\
\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\\
\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\Big)+\Delta y_{h1}\Big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\\
\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+\\
m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\Big)+\Delta y_{h2}\Big(\big(l^4(m_{h1}+\\
m_l)(m_{h3}+m_l)\big)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\big)\Big)+\\
\big((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\Big(\Delta y_{h3}\Big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\
\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\\
\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\Big)+\Delta y_{h2}\Big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\\
\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\\
\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\Big)+\Delta y_{h1}\Big(\big(l^4(m_{h2}+m_l)(m_{h3}+\\
m_l)\big)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\big)\big)\Big)/\big(den\, m_l^3\big)
\end{aligned}
$$

$$
\begin{aligned}
d(12) = -\Big(\big((\dot{x}_{h3}-\dot{x}_l)^2+(\dot{y}_{h3}-\dot{y}_l)^2+(\dot{z}_{h3}-\dot{z}_l)^2\big)\Big(\Delta z_{h2}\Big((\Delta x_{h1}\Delta x_{h2}+\\
\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+\\
m_l)(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\Big)+\Delta z_{h1}\Big((\Delta x_{h1}\Delta x_{h2}+\\
\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+\\
m_l)(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\Big)+\Delta z_{h3}\Big(\big(l^4(m_{h1}+\\
m_l)(m_{h2}+m_l)\big)/(m_{h1}m_{h2})-(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})^2\big)\Big)+\\
\big((\dot{x}_{h2}-\dot{x}_l)^2+(\dot{y}_{h2}-\dot{y}_l)^2+(\dot{z}_{h2}-\dot{z}_l)^2\big)\Big(\Delta z_{h3}\Big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\
\Delta z_{h1}\Delta z_{h2})(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})-\big(l^2(m_{h1}+m_l)(\Delta x_{h2}\Delta x_{h3}+\\
\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})\big)/(m_{h1})\Big)+\Delta z_{h1}\Big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\\
\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+\\
m_l)(\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\Big)+\Delta z_{h2}\Big(\big(l^4(m_{h1}+\\
m_l)(m_{h3}+m_l)\big)/(m_{h1}m_{h3})-(\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})^2\big)\Big)+\\
\big((\dot{x}_{h1}-\dot{x}_l)^2+(\dot{y}_{h1}-\dot{y}_l)^2+(\dot{z}_{h1}-\dot{z}_l)^2\big)\Big(\Delta z_{h3}\Big((\Delta x_{h1}\Delta x_{h2}+\Delta y_{h1}\Delta y_{h2}+\\
\Delta z_{h1}\Delta z_{h2})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h2}+m_l)(\Delta x_{h1}\Delta x_{h3}+\\
\Delta y_{h1}\Delta y_{h3}+\Delta z_{h1}\Delta z_{h3})\big)/(m_{h2})\Big)+\Delta z_{h2}\Big((\Delta x_{h1}\Delta x_{h3}+\Delta y_{h1}\Delta y_{h3}+\\
\Delta z_{h1}\Delta z_{h3})(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})-\big(l^2(m_{h3}+m_l)(\Delta x_{h1}\Delta x_{h2}+\\
\Delta y_{h1}\Delta y_{h2}+\Delta z_{h1}\Delta z_{h2})\big)/(m_{h3})\Big)+\Delta z_{h1}\Big(\big(l^4(m_{h2}+m_l)(m_{h3}+\\
m_l)\big)/(m_{h2}m_{h3})-(\Delta x_{h2}\Delta x_{h3}+\Delta y_{h2}\Delta y_{h3}+\Delta z_{h2}\Delta z_{h3})^2\big)\big)\Big)/\big(den\, m_l^3\big)+G+\ddot{z}_l
\end{aligned}
$$

# 7 Dynamic Equations of the Flexible Rope Model

This chapter presents the dynamic equations of the flexible rope model. The model has been designed using the Kane method and the equations have been generated using the tool Autolev. The equations for three particular configurations $n \in \{1, 2, 5\}$, composed of one, two and five mass points, are provided.

## 7.1 Composed of One Mass Point

The equation of this configuration is only provided for the validation of the modeling approach. At least five mass points are required for the model, to reflect the motion of LTD, rope and load correctly, see Sec. 7.3.

For $n = 1$ the following equation is derived:

$$\ddot{\alpha}_1 = -\left(-\cos\left(\alpha_1\right) F_1 + G \sin\left(\alpha_1\right) m_1 + k_1 l_1 \dot{\alpha}_1\right) / \left(l_1 m_1\right)$$

Where $\alpha_1$ is the pendulum angle, with $\dot{\alpha}_1 = \alpha_1 \, \mathrm{d}/\mathrm{d}t$ and $\ddot{\alpha}_1 = \alpha_1 \, \mathrm{d}^2/\mathrm{d}t^2$. The constants $l_1$, $m_1$ denote pendulum length and pendulum mass respectively. The coefficient $k_1$ describes the friction in the pendulum joint and the force $F_1$ can be used to stimulate the pendulum. It is easy to see, that for $k_1 = 0$ and $F_1 = 0$ the equation become equivalent to the dynamic equation of an idealized pendulum.

## 7.2 Composed of Two Mass Points

Similar to Sec. 7.1, the equations of this configuration are only provided for the validation of the modeling approach. At least five mass point are required for the model, to reflect the motion of LTD, rope and load correctly, see Sec. 7.3.

For $n = 2$ the following equations are derived:

$$\begin{aligned}
\ddot{\alpha}_1 = &\left(k_2 l_1 \dot{\alpha}_1 \cos^2\left(\alpha_2\right) + \left(\sin\left(\alpha_2\right) l_1 m_2 \dot{\alpha}_1^2 - \cos\left(\alpha_1 + \alpha_2\right) F_2 + G \sin\left(\alpha_1 + \right.\right.\right. \\
&\left.\left.\left.\alpha_2\right) m_2\right) \cos\left(\alpha_2\right) + \sin\left(\alpha_2\right) l_2 m_2 \left(\dot{\alpha}_1 + \dot{\alpha}_2\right)^2 + \cos\left(\alpha_1\right) \left(F_1 + \right. \\
&\left.F_2\right) - G \sin\left(\alpha_1\right) \left(m_1 + m_2\right) - \left(k_1 + k_2\right) l_1 \dot{\alpha}_1\right) / \left(l_1 \left(-m_2 \cos^2\left(\alpha_2\right) + m_1 + m_2\right)\right) \\
\ddot{\alpha}_2 = &-\left(2 \left(\left(\left(\left(m_1 + m_2\right) l_1^2 + 2 \cos\left(\alpha_2\right) l_2 m_2 l_1 + l_2^2 m_2\right) \left(-\cos\left(\alpha_1 + \alpha_2\right) F_2 + \right.\right.\right. \right. \\
&G \sin\left(\alpha_1 + \alpha_2\right) m_2 + l_1 \dot{\alpha}_1 \left(\cos\left(\alpha_2\right) k_2 + \sin\left(\alpha_2\right) m_2 \dot{\alpha}_1\right) + k_2 l_2 \left(\dot{\alpha}_1 + \\
&\left.\left.\left.\dot{\alpha}_2\right)\right)\right) / \left(m_2\right) - \left(\cos\left(\alpha_2\right) l_1 + l_2\right) \left(k_1 \dot{\alpha}_1 l_1^2 - \cos\left(\alpha_1\right) \left(F_1 + F_2\right) l_1 + G \sin\left(\alpha_1\right) \left(m_1 + \right.\right. \\
&\left.\left.m_2\right) l_1 + \cos\left(\alpha_2\right) k_2 l_2 \left(2 \dot{\alpha}_1 + \dot{\alpha}_2\right) l_1 + k_2 \left(\dot{\alpha}_1 l_1^2 + l_2^2 \left(\dot{\alpha}_1 + \dot{\alpha}_2\right)\right) - l_2 \left(\cos\left(\alpha_1 + \alpha_2\right) F_2 + \right. \right. \\
&\left.\left.\left.\left.m_2 \left(\sin\left(\alpha_2\right) l_1 \dot{\alpha}_2 \left(2 \dot{\alpha}_1 + \dot{\alpha}_2\right) - G \sin\left(\alpha_1 + \alpha_2\right)\right)\right)\right)\right)\right) / \left(l_1^2 l_2 \left(2 m_1 - \cos\left(2 \alpha_2\right) m_2 + m_2\right)\right)
\end{aligned}$$

Where $\alpha_i$ is the angle of the $i$'th pendulum, with $\dot{\alpha}_i = \alpha_i \,\mathrm{d}/\mathrm{d}t$ and $\ddot{\alpha}_i = \alpha_i \,\mathrm{d}^2/\mathrm{d}t^2$. The constants $l_i$, $m_i$ denote length and mass of the pendulum respectively. The coefficient $k_i$ describes the friction in the $i$'th pendulum joint and the force $F_i$ can be used to stimulate the $i$'th pendulum. For $k_{1,2} = 0$ and $F_{1,2} = 0$ the equations become equivalent to the dynamic equations of an idealized double pendulum:

$$\ddot{\alpha}_1 = \left(m_2 \left(G\cos\left(\alpha_2\right)\sin\left(\alpha_1+\alpha_2\right) + \sin\left(\alpha_2\right)\left(\cos\left(\alpha_2\right) l_1 \dot{\alpha}_1^2 + l_2\left(\dot{\alpha}_1 + \dot{\alpha}_2\right)^2\right)\right) - G\sin\left(\alpha_1\right)\left(m_1+m_2\right)\right) / \left(l_1\left(-m_2\cos^2\left(\alpha_2\right)+m_1+m_2\right)\right)$$

$$\ddot{\alpha}_2 = \left(G\sin\left(\alpha_1\right) l_2 \left(2m_1 - \cos\left(2\alpha_2\right) m_2 + m_2\right) - 2\sin\left(\alpha_2\right)\left(l_1^2\left(m_1+m_2\right)\dot{\alpha}_1^2 + l_2^2 m_2\left(\dot{\alpha}_1+\dot{\alpha}_2\right)^2 + G\cos\left(\alpha_1\right)\left(\cos\left(\alpha_2\right) l_2 m_2 + l_1\left(m_1+m_2\right)\right) + \cos\left(\alpha_2\right) l_1 l_2 m_2 \left(2\dot{\alpha}_1^2 + 2\dot{\alpha}_2\dot{\alpha}_1 + \dot{\alpha}_2^2\right)\right)\right) / \left(2 l_1 l_2 \left(-m_2\cos^2\left(\alpha_2\right)+m_1+m_2\right)\right)$$

## 7.3 Composed of Five Mass Points

The configuration presented in this section is composed of five consecutive pendulums. With a growing number of consecutive pendulums the generated equations quickly become larger. Therefore, $n = 5$ has been chosen as tradeoff between model complexity and size of the generated equations. The author considers this to be the smallest feasible configuration for the approximation of LTD, flexible rope and load. The topmost and lowermost mass points model the motion of LTD and load respectively. The three intermediate mass points model the motion of the flexible rope.

The variable $\alpha_i$ represents the angle of the $i$'th pendulum, with $\dot{\alpha}_i = \alpha_i \,\mathrm{d}/\mathrm{d}t$ and $\ddot{\alpha}_i = \alpha_i \,\mathrm{d}^2/\mathrm{d}t^2$. The constants $l_i$, $m_i$ denote length and mass of the pendulum respectively. The coefficient $k_i$ describes the friction in the $i$'th pendulum joint and the force $F_i$ can be used to stimulate the $i$'th pendulum. The variables $z_{xyz}$ represent intermediate results, which are created automatically during the generation of the equations.

The following equations have been generated for the model:

$$\begin{aligned}
z_6 &= \cos(\alpha_1) \\
z_7 &= \sin(\alpha_1) \\
z_{16} &= z_6^2 + z_7^2 \\
z_{21} &= l_1 * z_{16} \\
z_8 &= \cos(\alpha_1 + \alpha_2) \\
z_9 &= \sin(\alpha_1 + \alpha_2) \\
z_{17} &= z_8^2 + z_9^2 \\
z_{22} &= l_2 * z_{17} \\
z_{10} &= \cos(\alpha_1 + \alpha_2 + \alpha_3) \\
z_{11} &= \sin(\alpha_1 + \alpha_2 + \alpha_3)
\end{aligned}$$

$$z_{18} = z_{10}^2 + z_{11}^2$$

$$z_{23} = l_3 * z_{18}$$

$$z_{12} = \cos(\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4)$$

$$z_{13} = \sin(\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4)$$

$$z_{19} = z_{12}^2 + z_{13}^2$$

$$z_{24} = l_4 * z_{19}$$

$$z_{14} = \cos(\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5)$$

$$z_{15} = \sin(\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5)$$

$$z_{20} = z_{14}^2 + z_{15}^2$$

$$z_{25} = l_5 * z_{20}$$

$$z_{72} = G * m_1$$

$$z_{57} = k_1 * z_{21} * \dot{\alpha}_1$$

$$z_{73} = G * m_2$$

$$z_{74} = G * m_3$$

$$z_{75} = G * m_4$$

$$z_{76} = G * m_5$$

$$z_{58} = k_2 * z_{21} * \dot{\alpha}_1$$

$$z_{60} = k_3 * z_{21} * \dot{\alpha}_1$$

$$z_{63} = k_4 * z_{21} * \dot{\alpha}_1$$

$$z_{67} = k_5 * z_{21} * \dot{\alpha}_1$$

$$z_{59} = k_2 * z_{22} * (\dot{\alpha}_1 + \dot{\alpha}_2)$$

$$z_{61} = k_3 * z_{22} * (\dot{\alpha}_1 + \dot{\alpha}_2)$$

$$z_{64} = k_4 * z_{22} * (\dot{\alpha}_1 + \dot{\alpha}_2)$$

$$z_{68} = k_5 * z_{22} * (\dot{\alpha}_1 + \dot{\alpha}_2)$$

$$z_{62} = k_3 * z_{23} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3)$$

$$z_{65} = k_4 * z_{23} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3)$$

$$z_{69} = k_5 * z_{23} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3)$$

$$z_{66} = k_4 * z_{24} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4)$$

$$z_{70} = k_5 * z_{24} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4)$$

$$z_{71} = k_5 * z_{25} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4 + \dot{\alpha}_5)$$

$$z_{77} = z_6 * z_8 + z_7 * z_9$$

$$z_{80} = z_6 * z_{10} + z_7 * z_{11}$$

$$z_{86} = z_6 * z_{12} + z_7 * z_{13}$$

$$z_{95} = z_6 * z_{14} + z_7 * z_{15}$$

$$z_{83} = z_8 * z_{10} + z_9 * z_{11}$$

$$z_{89} = z_8 * z_{12} + z_9 * z_{13}$$

$$z_{98} = z_8 * z_{14} + z_9 * z_{15}$$

$$z_{92} = z_{10} * z_{12} + z_{11} * z_{13}$$

$$z_{101} = z_{10} * z_{14} + z_{11} * z_{15}$$

$$z_{104} = z_{12} * z_{14} + z_{13} * z_{15}$$

$$\begin{aligned} z_{107} = {} & F_2 * z_6 * z_{21} + F_2 * z_8 * z_{22} + F_3 * z_6 * z_{21} + F_3 * z_8 * z_{22} + F_3 * z_{10} * z_{23} + \\ & F_4 * z_6 * z_{21} + F_4 * z_8 * z_{22} + F_4 * z_{10} * z_{23} + F_4 * z_{12} * z_{24} + F_5 * z_6 * z_{21} + \\ & F_5 * z_8 * z_{22} + F_5 * z_{10} * z_{23} + F_5 * z_{12} * z_{24} + F_5 * z_{14} * z_{25} + \\ & z_{21} * (F_1 * z_6 - z_{72} * z_7 - z_{57}) - z_{73} * z_7 * z_{21} - z_{73} * z_9 * z_{22} - z_{74} * z_7 * z_{21} - z_{74} * z_9 \\ & * z_{22} - z_{74} * z_{11} * z_{23} - z_{75} * z_7 * z_{21} - z_{75} * z_9 * z_{22} - z_{75} * z_{11} * z_{23} - z_{75} * z_{13} \\ & * z_{24} - z_{76} * z_7 * z_{21} - z_{76} * z_9 * z_{22} - z_{76} * z_{11} * z_{23} - z_{76} * z_{13} * z_{24} - z_{76} * z_{15} \\ & * z_{25} - z_{21} * z_{58} - z_{21} * z_{60} - z_{21} * z_{63} - z_{21} * z_{67} - z_{22} * z_{59} - z_{22} * z_{61} - z_{22} * z_{64} \\ & - z_{22} * z_{68} - z_{23} * z_{62} - z_{23} * z_{65} - z_{23} * z_{69} - z_{24} * z_{66} - z_{24} * z_{70} - z_{25} * z_{71} - z_{21} \\ & * z_{77} * z_{59} - z_{21} * z_{77} * z_{61} - z_{21} * z_{77} * z_{64} - z_{21} * z_{77} * z_{68} - z_{21} * z_{80} * z_{62} - z_{21} \\ & * z_{80} * z_{65} - z_{21} * z_{80} * z_{69} - z_{21} * z_{86} * z_{66} - z_{21} * z_{86} * z_{70} - z_{21} * z_{95} * z_{71} - z_{22} \\ & * z_{77} * z_{58} - z_{22} * z_{77} * z_{60} - z_{22} * z_{77} * z_{63} - z_{22} * z_{77} * z_{67} - z_{22} * z_{83} * z_{62} - z_{22} \\ & * z_{83} * z_{65} - z_{22} * z_{83} * z_{69} - z_{22} * z_{89} * z_{66} - z_{22} * z_{89} * z_{70} - z_{22} * z_{98} * z_{71} - z_{23} \\ & * z_{80} * z_{60} - z_{23} * z_{80} * z_{63} - z_{23} * z_{80} * z_{67} - z_{23} * z_{83} * z_{61} - z_{23} * z_{83} * z_{64} - z_{23} \\ & * z_{83} * z_{68} - z_{23} * z_{92} * z_{66} - z_{23} * z_{92} * z_{70} - z_{23} * z_{101} * z_{71} - z_{24} * z_{86} * z_{63} - z_{24} \\ & * z_{86} * z_{67} - z_{24} * z_{89} * z_{64} - z_{24} * z_{89} * z_{68} - z_{24} * z_{92} * z_{65} - z_{24} * z_{92} * z_{69} - z_{24} \\ & * z_{104} * z_{71} - z_{25} * z_{95} * z_{67} - z_{25} * z_{98} * z_{68} - z_{25} * z_{101} * z_{69} - z_{25} * z_{104} * z_{70} \end{aligned}$$

$$z_{31} = z_8 * (\dot{\alpha}_1 + \dot{\alpha}_2)$$

$$z_{30} = z_9 * (\dot{\alpha}_1 + \dot{\alpha}_2)$$

$$z_{32} = 2 * z_9 * z_{31} - 2 * z_8 * z_{30}$$

$$z_{33} = l_2 * (\dot{\alpha}_1 + \dot{\alpha}_2) * z_{32}$$

$$z_{78} = z_7 * z_8 - z_6 * z_9$$

$$z_{29} = z_{22} * (\dot{\alpha}_1 + \dot{\alpha}_2)$$

$$z_{34} = z_{17} * (\dot{\alpha}_1 + \dot{\alpha}_2)$$

$$z_{35} = z_{29} * z_{34}$$

$$z_{79} = z_6 * z_9 - z_7 * z_8$$

$$z_{26} = z_{21} * \dot{\alpha}_1$$

$$z_{27} = z_{16} * \dot{\alpha}_1$$

$$z_{28} = z_{26} * z_{27}$$

$$z_{38} = z_{10} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3)$$

$$z_{37} = z_{11} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3)$$

$$z_{39} = 2 * z_{11} * z_{38} - 2 * z_{10} * z_{37}$$

$$z_{40} = l_3 * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3) * z_{39}$$

$$z_{81} = z_7 * z_{10} - z_6 * z_{11}$$

$$z_{36} = z_{23} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3)$$

$$z_{41} = z_{18} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3)$$

$$z_{42} = z_{36} * z_{41}$$

$$z_{84} = z_9 * z_{10} - z_8 * z_{11}$$

$$z_{82} = z_6 * z_{11} - z_7 * z_{10}$$

$$z_{85} = z_8 * z_{11} - z_9 * z_{10}$$

$$z_{45} = z_{12} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4)$$

$$z_{44} = z_{13} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4)$$

$$z_{46} = 2 * z_{13} * z_{45} - 2 * z_{12} * z_{44}$$

$$z_{47} = l_4 * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4) * z_{46}$$

$$z_{87} = z_7 * z_{12} - z_6 * z_{13}$$

$$z_{43} = z_{24} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4)$$

$$z_{48} = z_{19} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4)$$

$$z_{49} = z_{43} * z_{48}$$

$$z_{90} = z_9 * z_{12} - z_8 * z_{13}$$

$$z_{93} = z_{11} * z_{12} - z_{10} * z_{13}$$

$$z_{88} = z_6 * z_{13} - z_7 * z_{12}$$

$$z_{91} = z_8 * z_{13} - z_9 * z_{12}$$

$$z_{94} = z_{10} * z_{13} - z_{11} * z_{12}$$

$$z_{52} = z_{14} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4 + \dot{\alpha}_5)$$

$$z_{51} = z_{15} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4 + \dot{\alpha}_5)$$

$$z_{53} = 2 * z_{15} * z_{52} - 2 * z_{14} * z_{51}$$

$$z_{54} = l_5 * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4 + \dot{\alpha}_5) * z_{53}$$

$$z_{96} = z_7 * z_{14} - z_6 * z_{15}$$

$$z_{50} = z_{25} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4 + \dot{\alpha}_5)$$

$$z_{55} = z_{20} * (\dot{\alpha}_1 + \dot{\alpha}_2 + \dot{\alpha}_3 + \dot{\alpha}_4 + \dot{\alpha}_5)$$

$$z_{56} = z_{50} * z_{55}$$

$$z_{99} = z_9 * z_{14} - z_8 * z_{15}$$

$$z_{102} = z_{11} * z_{14} - z_{10} * z_{15}$$

$$z_{105} = z_{13} * z_{14} - z_{12} * z_{15}$$

$$z_{97} = z_6 * z_{15} - z_7 * z_{14}$$

$$z_{100} = z_8 * z_{15} - z_9 * z_{14}$$

$$z_{103} = z_{10} * z_{15} - z_{11} * z_{14}$$

$$z_{106} = z_{12} * z_{15} - z_{13} * z_{14}$$

$$\begin{aligned} z_{117} = {} & m_2 * (z_{22} * z_{33} + z_{21} * z_{77} * z_{33} + z_{21} * z_{78} * z_{35} + z_{22} * z_{79} * z_{28}) + \\ & m_3 * (z_{22} * z_{33} + z_{23} * z_{40} + z_{21} * z_{77} * z_{33} + z_{21} * z_{78} * z_{35} + z_{21} * z_{80} * z_{40} + \\ & z_{21} * z_{81} * z_{42} + z_{22} * z_{79} * z_{28} + z_{22} * z_{83} * z_{40} + z_{22} * z_{84} * z_{42} + z_{23} * z_{82} * z_{28} + \\ & z_{23} * z_{83} * z_{33} + z_{23} * z_{85} * z_{35}) + m_4 * (z_{22} * z_{33} + z_{23} * z_{40} + z_{24} * z_{47} + \\ & z_{21} * z_{77} * z_{33} + z_{21} * z_{78} * z_{35} + z_{21} * z_{80} * z_{40} + z_{21} * z_{81} * z_{42} + z_{21} * z_{86} * z_{47} + \\ & z_{21} * z_{87} * z_{49} + z_{22} * z_{79} * z_{28} + z_{22} * z_{83} * z_{40} + z_{22} * z_{84} * z_{42} + z_{22} * z_{89} * z_{47} + \\ & z_{22} * z_{90} * z_{49} + z_{23} * z_{82} * z_{28} + z_{23} * z_{83} * z_{33} + z_{23} * z_{85} * z_{35} + z_{23} * z_{92} * z_{47} + \\ & z_{23} * z_{93} * z_{49} + z_{24} * z_{88} * z_{28} + z_{24} * z_{89} * z_{33} + z_{24} * z_{91} * z_{35} + z_{24} * z_{92} * z_{40} + \\ & z_{24} * z_{94} * z_{42}) + m_5 * (z_{22} * z_{33} + z_{23} * z_{40} + z_{24} * z_{47} + z_{25} * z_{54} + z_{21} * z_{77} * z_{33} + \\ & z_{21} * z_{78} * z_{35} + z_{21} * z_{80} * z_{40} + z_{21} * z_{81} * z_{42} + z_{21} * z_{86} * z_{47} + z_{21} * z_{87} * z_{49} + \\ & z_{21} * z_{95} * z_{54} + z_{21} * z_{96} * z_{56} + z_{22} * z_{79} * z_{28} + z_{22} * z_{83} * z_{40} + z_{22} * z_{84} * z_{42} + \\ & z_{22} * z_{89} * z_{47} + z_{22} * z_{90} * z_{49} + z_{22} * z_{98} * z_{54} + z_{22} * z_{99} * z_{56} + z_{23} * z_{82} * z_{28} + \\ & z_{23} * z_{83} * z_{33} + z_{23} * z_{85} * z_{35} + z_{23} * z_{92} * z_{47} + z_{23} * z_{93} * z_{49} + z_{23} * z_{101} * z_{54} + \\ & z_{23} * z_{102} * z_{56} + z_{24} * z_{88} * z_{28} + z_{24} * z_{89} * z_{33} + z_{24} * z_{91} * z_{35} + z_{24} * z_{92} * z_{40} + \\ & z_{24} * z_{94} * z_{42} + z_{24} * z_{104} * z_{54} + z_{24} * z_{105} * z_{56} + z_{25} * z_{97} * z_{28} + z_{25} * z_{98} * z_{33} + \\ & z_{25} * z_{100} * z_{35} + z_{25} * z_{101} * z_{40} + z_{25} * z_{103} * z_{42} + z_{25} * z_{104} * z_{47} + z_{25} * z_{106} * z_{49}) \end{aligned}$$

$$z_{132} = z_{107} - z_{117}$$

$$\begin{aligned} z_{113} = {} & m_2 * z_{22} * (z_{22} + z_{21} * z_{77}) + m_3 * (z_{22}^2 + z_{23}^2 + z_{21} * z_{22} * z_{77} + \\ & z_{21} * z_{23} * z_{80} + 2 * z_{22} * z_{23} * z_{83}) + m_4 * (z_{22}^2 + z_{23}^2 + z_{24}^2 + z_{21} * z_{22} * z_{77} + \\ & z_{21} * z_{23} * z_{80} + z_{21} * z_{24} * z_{86} + 2 * z_{22} * z_{23} * z_{83} + 2 * z_{22} * z_{24} * z_{89} + \\ & 2 * z_{23} * z_{24} * z_{92}) + m_5 * (z_{22}^2 + z_{23}^2 + z_{24}^2 + z_{25}^2 + z_{21} * z_{22} * z_{77} + z_{21} * z_{23} * z_{80} + \\ & z_{21} * z_{24} * z_{86} + z_{21} * z_{25} * z_{95} + 2 * z_{22} * z_{23} * z_{83} + 2 * z_{22} * z_{24} * z_{89} + \\ & 2 * z_{22} * z_{25} * z_{98} + 2 * z_{23} * z_{24} * z_{92} + 2 * z_{23} * z_{25} * z_{101} + 2 * z_{24} * z_{25} * z_{104}) \end{aligned}$$

$$z_{112} = m_1 * z_{21}^2 + m_2 * (z_{21}^2 + z_{22}^2 + 2 * z_{21} * z_{22} * z_{77}) + m_3 * (z_{21}^2 + z_{22}^2 + z_{23}^2 + 2 * z_{21} * z_{22} * z_{77} + 2 * z_{21} * z_{23} * z_{80} + 2 * z_{22} * z_{23} * z_{83}) + m_4 * (z_{21}^2 + z_{22}^2 + z_{23}^2 + z_{24}^2 + 2 * z_{21} * z_{22} * z_{77} + 2 * z_{21} * z_{23} * z_{80} + 2 * z_{21} * z_{24} * z_{86} + 2 * z_{22} * z_{23} * z_{83} + 2 * z_{22} * z_{24} * z_{89} + 2 * z_{23} * z_{24} * z_{92}) + m_5 * (z_{21}^2 + z_{22}^2 + z_{23}^2 + z_{24}^2 + z_{25}^2 + 2 * z_{21} * z_{22} * z_{77} + 2 * z_{21} * z_{23} * z_{80} + 2 * z_{21} * z_{24} * z_{86} + 2 * z_{21} * z_{25} * z_{95} + 2 * z_{22} * z_{23} * z_{83} + 2 * z_{22} * z_{24} * z_{89} + 2 * z_{22} * z_{25} * z_{98} + 2 * z_{23} * z_{24} * z_{92} + 2 * z_{23} * z_{25} * z_{101} + 2 * z_{24} * z_{25} * z_{104})$$

$$z_{137} = z_{113} / z_{112}$$

$$z_{108} = F_3 * z_8 * z_{22} + F_3 * z_{10} * z_{23} + F_4 * z_8 * z_{22} + F_4 * z_{10} * z_{23} + F_4 * z_{12} * z_{24} + F_5 * z_8 * z_{22} + F_5 * z_{10} * z_{23} + F_5 * z_{12} * z_{24} + F_5 * z_{14} * z_{25} + z_{22} * (F_2 * z_8 - z_{73} * z_9 - z_{59} - z_{77} * z_{58}) - z_{74} * z_9 * z_{22} - z_{74} * z_{11} * z_{23} - z_{75} * z_9 * z_{22} - z_{75} * z_{11} * z_{23} - z_{75} * z_{13} * z_{24} - z_{76} * z_9 * z_{22} - z_{76} * z_{11} * z_{23} - z_{76} * z_{13} * z_{24} - z_{76} * z_{15} * z_{25} - z_{22} * z_{61} - z_{22} * z_{64} - z_{22} * z_{68} - z_{23} * z_{62} - z_{23} * z_{65} - z_{23} * z_{69} - z_{24} * z_{66} - z_{24} * z_{70} - z_{25} * z_{71} - z_{22} * z_{77} * z_{60} - z_{22} * z_{77} * z_{63} - z_{22} * z_{77} * z_{67} - z_{22} * z_{83} * z_{62} - z_{22} * z_{83} * z_{65} - z_{22} * z_{83} * z_{69} - z_{22} * z_{89} * z_{66} - z_{22} * z_{89} * z_{70} - z_{22} * z_{98} * z_{71} - z_{23} * z_{80} * z_{60} - z_{23} * z_{80} * z_{63} - z_{23} * z_{80} * z_{67} - z_{23} * z_{83} * z_{61} - z_{23} * z_{83} * z_{64} - z_{23} * z_{83} * z_{68} - z_{23} * z_{92} * z_{66} - z_{23} * z_{92} * z_{70} - z_{23} * z_{101} * z_{71} - z_{24} * z_{86} * z_{63} - z_{24} * z_{86} * z_{67} - z_{24} * z_{89} * z_{64} - z_{24} * z_{89} * z_{68} - z_{24} * z_{92} * z_{65} - z_{24} * z_{92} * z_{69} - z_{24} * z_{104} * z_{71} - z_{25} * z_{95} * z_{67} - z_{25} * z_{98} * z_{68} - z_{25} * z_{101} * z_{69} - z_{25} * z_{104} * z_{70}$$

$$z_{122} = m_2 * z_{22} * (z_{33} + z_{79} * z_{28}) + m_3 * (z_{22} * z_{33} + z_{23} * z_{40} + z_{22} * z_{79} * z_{28} + z_{22} * z_{83} * z_{40} + z_{22} * z_{84} * z_{42} + z_{23} * z_{82} * z_{28} + z_{23} * z_{83} * z_{33} + z_{23} * z_{85} * z_{35}) + m_4 * (z_{22} * z_{33} + z_{23} * z_{40} + z_{24} * z_{47} + z_{22} * z_{79} * z_{28} + z_{22} * z_{83} * z_{40} + z_{22} * z_{84} * z_{42} + z_{22} * z_{89} * z_{47} + z_{22} * z_{90} * z_{49} + z_{23} * z_{82} * z_{28} + z_{23} * z_{83} * z_{33} + z_{23} * z_{85} * z_{35} + z_{23} * z_{92} * z_{47} + z_{23} * z_{93} * z_{49} + z_{24} * z_{88} * z_{28} + z_{24} * z_{89} * z_{33} + z_{24} * z_{91} * z_{35} + z_{24} * z_{92} * z_{40} + z_{24} * z_{94} * z_{42}) + m_5 * (z_{22} * z_{33} + z_{23} * z_{40} + z_{24} * z_{47} + z_{25} * z_{54} + z_{22} * z_{79} * z_{28} + z_{22} * z_{83} * z_{40} + z_{22} * z_{84} * z_{42} + z_{22} * z_{89} * z_{47} + z_{22} * z_{90} * z_{49} + z_{22} * z_{98} * z_{54} + z_{22} * z_{99} * z_{56} + z_{23} * z_{82} * z_{28} + z_{23} * z_{83} * z_{33} + z_{23} * z_{85} * z_{35} + z_{23} * z_{92} * z_{47} + z_{23} * z_{93} * z_{49} + z_{23} * z_{101} * z_{54} + z_{23} * z_{102} * z_{56} + z_{24} * z_{88} * z_{28} + z_{24} * z_{89} * z_{33} + z_{24} * z_{91} * z_{35} + z_{24} * z_{92} * z_{40} + z_{24} * z_{94} * z_{42} + z_{24} * z_{104} * z_{54} + z_{24} * z_{105} * z_{56} + z_{25} * z_{97} * z_{28} + z_{25} * z_{98} * z_{33} + z_{25} * z_{100} * z_{35} + z_{25} * z_{101} * z_{40} + z_{25} * z_{103} * z_{42} + z_{25} * z_{104} * z_{47} + z_{25} * z_{106} * z_{49})$$

$$z_{133} = z_{108} - z_{122}$$

$$z_{142} = z_{137} * z_{132} - z_{133}$$

$$z_{114} = m_3 * z_{23} * (z_{23} + z_{21} * z_{80} + z_{22} * z_{83}) + m_4 * (z_{23}^2 + z_{24}^2 + z_{21} * z_{23} * z_{80} + z_{21} * z_{24} * z_{86} + z_{22} * z_{23} * z_{83} + z_{22} * z_{24} * z_{89} + 2 * z_{23} * z_{24} * z_{92}) + m_5 * (z_{23}^2 + z_{24}^2 + z_{25}^2 + z_{21} * z_{23} * z_{80} + z_{21} * z_{24} * z_{86} + z_{21} * z_{25} * z_{95} + z_{22} * z_{23} * z_{83} + z_{22} * z_{24} * z_{89} + z_{22} * z_{25} * z_{98} + 2 * z_{23} * z_{24} * z_{92} + 2 * z_{23} * z_{25} * z_{101} + 2 * z_{24} * z_{25} * z_{104})$$

$$z_{119} = m_3 * z_{23} * (z_{23} + z_{22} * z_{83}) + m_4 * (z_{23}^2 + z_{24}^2 + z_{22} * z_{23} * z_{83} + z_{22} * z_{24} * z_{89} + 2 * z_{23} * z_{24} * z_{92}) + m_5 * (z_{23}^2 + z_{24}^2 + z_{25}^2 + z_{22} * z_{23} * z_{83} + z_{22} * z_{24} * z_{89} + z_{22} * z_{25} * z_{98} + 2 * z_{23} * z_{24} * z_{92} + 2 * z_{23} * z_{25} * z_{101} + 2 * z_{24} * z_{25} * z_{104})$$

$$z_{139} = z_{114} * z_{137} - z_{119}$$

$$z_{143} = z_{114} / z_{112}$$

$$z_{109} = F_4 * z_{10} * z_{23} + F_4 * z_{12} * z_{24} + F_5 * z_{10} * z_{23} + F_5 * z_{12} * z_{24} + F_5 * z_{14} * z_{25} + z_{23} * (F_3 * z_{10} - z_{74} * z_{11} - z_{62} - z_{80} * z_{60} - z_{83} * z_{61}) - z_{75} * z_{11} * z_{23} - z_{75} * z_{13} * z_{24} - z_{76} * z_{11} * z_{23} - z_{76} * z_{13} * z_{24} - z_{76} * z_{15} * z_{25} - z_{23} * z_{65} - z_{23} * z_{69} - z_{24} * z_{66} - z_{24} * z_{70} - z_{25} * z_{71} - z_{23} * z_{80} * z_{63} - z_{23} * z_{80} * z_{67} - z_{23} * z_{83} * z_{64} - z_{23} * z_{83} * z_{68} - z_{23} * z_{92} * z_{66} - z_{23} * z_{92} * z_{70} - z_{23} * z_{101} * z_{71} - z_{24} * z_{86} * z_{63} - z_{24} * z_{86} * z_{67} - z_{24} * z_{89} * z_{64} - z_{24} * z_{89} * z_{68} - z_{24} * z_{92} * z_{65} - z_{24} * z_{92} * z_{69} - z_{24} * z_{104} * z_{71} - z_{25} * z_{95} * z_{67} - z_{25} * z_{98} * z_{68} - z_{25} * z_{101} * z_{69} - z_{25} * z_{104} * z_{70}$$

$$z_{126} = m_3 * z_{23} * (z_{40} + z_{82} * z_{28} + z_{83} * z_{33} + z_{85} * z_{35}) + m_4 * (z_{23} * z_{40} + z_{24} * z_{47} + z_{23} * z_{82} * z_{28} + z_{23} * z_{83} * z_{33} + z_{23} * z_{85} * z_{35} + z_{23} * z_{92} * z_{47} + z_{23} * z_{93} * z_{49} + z_{24} * z_{88} * z_{28} + z_{24} * z_{89} * z_{33} + z_{24} * z_{91} * z_{35} + z_{24} * z_{92} * z_{40} + z_{24} * z_{94} * z_{42}) + m_5 * (z_{23} * z_{40} + z_{24} * z_{47} + z_{25} * z_{54} + z_{23} * z_{82} * z_{28} + z_{23} * z_{83} * z_{33} + z_{23} * z_{85} * z_{35} + z_{23} * z_{92} * z_{47} + z_{23} * z_{93} * z_{49} + z_{23} * z_{101} * z_{54} + z_{23} * z_{102} * z_{56} + z_{24} * z_{88} * z_{28} + z_{24} * z_{89} * z_{33} + z_{24} * z_{91} * z_{35} + z_{24} * z_{92} * z_{40} + z_{24} * z_{94} * z_{42} + z_{24} * z_{104} * z_{54} + z_{24} * z_{105} * z_{56} + z_{25} * z_{97} * z_{28} + z_{25} * z_{98} * z_{33} + z_{25} * z_{100} * z_{35} + z_{25} * z_{101} * z_{40} + z_{25} * z_{103} * z_{42} + z_{25} * z_{104} * z_{47} + z_{25} * z_{106} * z_{49})$$

$$z_{134} = z_{109} - z_{126}$$

$$z_{148} = z_{143} * z_{132} - z_{134}$$

$$z_{144} = z_{113} * z_{143} - z_{119}$$

$$z_{118} = m_2 * z_{22}^2 + m_3 * (z_{22}^2 + z_{23}^2 + 2 * z_{22} * z_{23} * z_{83}) + m_4 * (z_{22}^2 + z_{23}^2 + z_{24}^2 + 2 * z_{22} * z_{23} * z_{83} + 2 * z_{22} * z_{24} * z_{89} + 2 * z_{23} * z_{24} * z_{92}) + m_5 * (z_{22}^2 + z_{23}^2 + z_{24}^2 + z_{25}^2 + 2 * z_{22} * z_{23} * z_{83} + 2 * z_{22} * z_{24} * z_{89} + 2 * z_{22} * z_{25} * z_{98} + 2 * z_{23} * z_{24} * z_{92} + 2 * z_{23} * z_{25} * z_{101} + 2 * z_{24} * z_{25} * z_{104})$$

$$z_{138} = z_{113} * z_{137} - z_{118}$$

$$z_{161} = z_{144} / z_{138}$$

$$z_{165} = z_{148} - z_{161} * z_{142}$$

$$z_{115} = m_4 * z_{24} * (z_{24} + z_{21} * z_{86} + z_{22} * z_{89} + z_{23} * z_{92}) + m_5 * (z_{24}^2 + z_{25}^2 + z_{21} * z_{24} * z_{86} + z_{21} * z_{25} * z_{95} + z_{22} * z_{24} * z_{89} + z_{22} * z_{25} * z_{98} + z_{23} * z_{24} * z_{92} + z_{23} * z_{25} * z_{101} + 2 * z_{24} * z_{25} * z_{104})$$

$$z_{124} = m_4 * z_{24} * (z_{24} + z_{23} * z_{92}) + m_5 * (z_{24}^2 + z_{25}^2 + z_{23} * z_{24} * z_{92} + z_{23} * z_{25} * z_{101} + 2 * z_{24} * z_{25} * z_{104})$$

$$z_{146} = z_{115} * z_{143} - z_{124}$$

$$z_{120} = m_4 * z_{24} * (z_{24} + z_{22} * z_{89} + z_{23} * z_{92}) + m_5 * (z_{24}^2 + z_{25}^2 + z_{22} * z_{24} * z_{89} + z_{22} * z_{25} * z_{98} + z_{23} * z_{24} * z_{92} + z_{23} * z_{25} * z_{101} + 2 * z_{24} * z_{25} * z_{104})$$

$$z_{140} = z_{115} * z_{137} - z_{120}$$

$$z_{163} = z_{146} - z_{140} * z_{161}$$

$$z_{149} = z_{115} / z_{112}$$

$$z_{110} = F_5 * z_{12} * z_{24} + F_5 * z_{14} * z_{25} + z_{24} * (F_4 * z_{12} - z_{75} * z_{13} - z_{66} - z_{86} * z_{63} - z_{89} * z_{64} - z_{92} * z_{65}) - z_{76} * z_{13} * z_{24} - z_{76} * z_{15} * z_{25} - z_{24} * z_{70} - z_{25} * z_{71} - z_{24} * z_{86} * z_{67} - z_{24} * z_{89} * z_{68} - z_{24} * z_{92} * z_{69} - z_{24} * z_{104} * z_{71} - z_{25} * z_{95} * z_{67} - z_{25} * z_{98} * z_{68} - z_{25} * z_{101} * z_{69} - z_{25} * z_{104} * z_{70}$$

$$z_{129} = m_4 * z_{24} * (z_{47} + z_{88} * z_{28} + z_{89} * z_{33} + z_{91} * z_{35} + z_{92} * z_{40} + z_{94} * z_{42}) + m_5 * (z_{24} * z_{47} + z_{25} * z_{54} + z_{24} * z_{88} * z_{28} + z_{24} * z_{89} * z_{33} + z_{24} * z_{91} * z_{35} + z_{24} * z_{92} * z_{40} + z_{24} * z_{94} * z_{42} + z_{24} * z_{104} * z_{54} + z_{24} * z_{105} * z_{56} + z_{25} * z_{97} * z_{28} + z_{25} * z_{98} * z_{33} + z_{25} * z_{100} * z_{35} + z_{25} * z_{101} * z_{40} + z_{25} * z_{103} * z_{42} + z_{25} * z_{104} * z_{47} + z_{25} * z_{106} * z_{49})$$

$$z_{135} = z_{110} - z_{129}$$

$$z_{154} = z_{149} * z_{132} - z_{135}$$

$$z_{150} = z_{113} * z_{149} - z_{120}$$

$$z_{166} = z_{150} / z_{138}$$

$$z_{170} = z_{154} - z_{166} * z_{142}$$

$$z_{151} = z_{114} * z_{149} - z_{124}$$

$$z_{167} = z_{151} - z_{139} * z_{166}$$

$$z_{123} = m_3 * z_{23}^2 + m_4 * (z_{23}^2 + z_{24}^2 + 2 * z_{23} * z_{24} * z_{92}) + m_5 * (z_{23}^2 + z_{24}^2 + z_{25}^2 + 2 * z_{23} * z_{24} * z_{92} + 2 * z_{23} * z_{25} * z_{101} + 2 * z_{24} * z_{25} * z_{104})$$

$$z_{145} = z_{114} * z_{143} - z_{123}$$

$$z_{162} = z_{145} - z_{139} * z_{161}$$

$$z_{176} = z_{167} / z_{162}$$

$$z_{179} = z_{170} - z_{176} * z_{165}$$

$$z_{116} = m_5 * z_{25} * (z_{25} + z_{21} * z_{95} + z_{22} * z_{98} + z_{23} * z_{101} + z_{24} * z_{104})$$

$$z_{128} = m_5 * z_{25} * (z_{25} + z_{24} * z_{104})$$

$$z_{153} = z_{116} * z_{149} - z_{128}$$

$$z_{121} = m_5 * z_{25} * (z_{25} + z_{22} * z_{98} + z_{23} * z_{101} + z_{24} * z_{104})$$

$$z_{141} = z_{116} * z_{137} - z_{121}$$

$$z_{169} = z_{153} - z_{141} * z_{166}$$

$$
\begin{aligned}
z_{125} &= m_5 * z_{25} * (z_{25} + z_{23} * z_{101} + z_{24} * z_{104}) \\
z_{147} &= z_{116} * z_{143} - z_{125} \\
z_{164} &= z_{147} - z_{141} * z_{161} \\
z_{178} &= z_{169} - z_{164} * z_{176} \\
z_{155} &= z_{116} / z_{112} \\
z_{111} &= z_{25} * (F_5 * z_{14} - z_{76} * z_{15} - z_{71} - z_{95} * z_{67} - z_{98} * z_{68} - z_{101} * z_{69} - z_{104} * z_{70}) \\
z_{131} &= m_5 * z_{25} * (z_{54} + z_{97} * z_{28} + z_{98} * z_{33} + z_{100} * z_{35} + \\
&\quad z_{101} * z_{40} + z_{103} * z_{42} + z_{104} * z_{47} + z_{106} * z_{49}) \\
z_{136} &= z_{111} - z_{131} \\
z_{160} &= z_{155} * z_{132} - z_{136} \\
z_{156} &= z_{113} * z_{155} - z_{121} \\
z_{171} &= z_{156} / z_{138} \\
z_{175} &= z_{160} - z_{171} * z_{142} \\
z_{157} &= z_{114} * z_{155} - z_{125} \\
z_{172} &= z_{157} - z_{139} * z_{171} \\
z_{180} &= z_{172} / z_{162} \\
z_{183} &= z_{175} - z_{180} * z_{165} \\
z_{158} &= z_{115} * z_{155} - z_{128} \\
z_{173} &= z_{158} - z_{140} * z_{171} \\
z_{181} &= z_{173} - z_{163} * z_{180} \\
z_{127} &= m_4 * z_{24}^2 + m_5 * (z_{24}^2 + z_{25}^2 + 2 * z_{24} * z_{25} * z_{104}) \\
z_{152} &= z_{115} * z_{149} - z_{127} \\
z_{168} &= z_{152} - z_{140} * z_{166} \\
z_{177} &= z_{168} - z_{163} * z_{176} \\
z_{184} &= z_{181} / z_{177} \\
z_{186} &= z_{183} - z_{184} * z_{179} \\
z_{130} &= m_5 * z_{25}^2 \\
z_{159} &= z_{116} * z_{155} - z_{130} \\
z_{174} &= z_{159} - z_{141} * z_{171} \\
z_{182} &= z_{174} - z_{164} * z_{180} \\
z_{185} &= z_{182} - z_{178} * z_{184} \\
z_{187} &= z_{186} / z_{185} \\
z_{188} &= (z_{179} - z_{178} * z_{187}) / z_{177} \\
z_{189} &= (z_{165} - z_{163} * z_{188} - z_{164} * z_{187}) / z_{162} \\
z_{190} &= (z_{142} - z_{139} * z_{189} - z_{140} * z_{188} - z_{141} * z_{187}) / z_{138} \\
z_{191} &= (z_{132} - z_{113} * z_{190} - z_{114} * z_{189} - z_{115} * z_{188} - z_{116} * z_{187}) / z_{112} \\
\ddot{\alpha}_1 &= z_{191} \\
\ddot{\alpha}_2 &= z_{190} \\
\ddot{\alpha}_3 &= z_{189} \\
\ddot{\alpha}_4 &= z_{188} \\
\ddot{\alpha}_5 &= z_{187}
\end{aligned}
$$

# Bibliography

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