

$$\begin{aligned}
& k_0 \left(\eta_{P1}(t) - \eta_1(t) \right) - \frac{1}{2} M_{P1} \left(2 \left(-\cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \alpha'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) \right) \right. \\
& \quad \left(\cos(\theta(t)) R'(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) - \right. \\
& \quad \left. R(t) \sin(\theta(t)) \theta'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \right. \\
& \quad \left. \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) + \\
& \quad 2 \cos(\alpha(t)) \alpha'(t) \left(\cos(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \sin(\alpha(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) + \\
& \quad 2 \left(\cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \alpha'(t) \right) \\
& \quad \left(\sin(\theta(t)) R'(t) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \right. \\
& \quad \left. \cos(\theta(t)) R(t) \theta'(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \right. \\
& \quad \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) \Big) + \frac{1}{2} M_{P1} \\
& \quad \left(-2 \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \alpha'(t) \left(\cos(\theta(t)) R'(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \right. \right. \\
& \quad \left. \left. \alpha'(t) - R(t) \sin(\theta(t)) \theta'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \right. \right. \\
& \quad \left. \left. \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) - 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \right. \\
& \quad \left(\theta'(t) + \psi'(t) \right) \left(\cos(\theta(t)) R'(t) - \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) - \right. \\
& \quad \left. R(t) \sin(\theta(t)) \theta'(t) - \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \right. \\
& \quad \left. \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) + \\
& \quad 2 \cos(\alpha(t)) \alpha'(t) \left(\cos(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \sin(\alpha(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) - \\
& \quad 2 \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \alpha'(t) \\
& \quad \left(\sin(\theta(t)) R'(t) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \right. \\
& \quad \left. \cos(\theta(t)) R(t) \theta'(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \right. \\
& \quad \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) + 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \\
& \quad \left(\theta'(t) + \psi'(t) \right) \left(\sin(\theta(t)) R'(t) - \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t) + \right. \\
& \quad \left. \cos(\theta(t)) R(t) \theta'(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) + \right. \\
& \quad \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\eta_1'(t) + \eta_{P1}'(t)) \right) + \\
& \quad 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left(-\cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t)^2 + \right. \\
& \quad 2 \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t)) \alpha'(t) - \\
& \quad 2 \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) (\eta_1'(t) + \eta_{P1}'(t)) \alpha'(t) - \cos(\theta(t)) R(t) \theta'(t)^2 - \\
& \quad \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta'(t) + \psi'(t))^2 - 2 \sin(\theta(t)) R'(t) \theta'(t) - \\
& \quad 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (\theta'(t) + \psi'(t)) (\eta_1'(t) + \eta_{P1}'(t)) + \cos(\theta(t)) R''(t) - \\
& \quad \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha''(t) - R(t) \sin(\theta(t)) \theta''(t) - \\
& \quad \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) (\theta''(t) + \psi''(t)) + \\
& \quad \left. \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) (\eta_1''(t) + \eta_{P1}''(t)) \right) + \\
& \quad 2 \sin(\alpha(t)) \left(-\sin(\alpha(t)) (L_0 + \eta_1(t) + \eta_{P1}(t)) \alpha'(t)^2 + 2 \cos(\alpha(t)) (\eta_1'(t) + \eta_{P1}'(t)) \alpha'(t) + \right.
\end{aligned}$$

$$\begin{aligned}
& \cos(\alpha(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \alpha''(t) + \sin(\alpha(t)) \left(\eta_1''(t) + \eta_{P1}''(t) \right) \Big) + \\
& 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left(-\cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \alpha'(t)^2 - \right. \\
& 2 \cos(\theta(t) + \psi(t)) \sin(\alpha(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \left(\theta'(t) + \psi'(t) \right) \alpha'(t) - \\
& 2 \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \left(\eta_1'(t) + \eta_{P1}'(t) \right) \alpha'(t) - R(t) \sin(\theta(t)) \theta'(t)^2 - \\
& \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \left(\theta'(t) + \psi'(t) \right)^2 + 2 \cos(\theta(t)) R'(t) \theta'(t) + \\
& 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left(\theta'(t) + \psi'(t) \right) \left(\eta_1'(t) + \eta_{P1}'(t) \right) + \sin(\theta(t)) R''(t) - \\
& \sin(\alpha(t)) \sin(\theta(t) + \psi(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \alpha''(t) + \cos(\theta(t)) R(t) \theta''(t) + \\
& \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \left(\theta''(t) + \psi''(t) \right) + \\
& \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left(\eta_1''(t) + \eta_{P1}''(t) \right) \right) \Big) + \\
& \left(\mu M_{P1} \left(2 \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \sin^2(\alpha(t)) + 2 \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \right. \right. \\
& \left. \left(\cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \right) + \right. \\
& \left. \left. 2 \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left(R(t) \sin(\theta(t)) + \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \right) \right) \right) \Big) / \\
& \left(2 \left(\sin^2(\alpha(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right)^2 + \right. \right. \\
& \left. \left(\cos(\theta(t)) R(t) + \cos(\alpha(t)) \cos(\theta(t) + \psi(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \right)^2 + \left(R(t) \sin(\theta(t)) + \right. \right. \\
& \left. \left. \left. \cos(\alpha(t)) \sin(\theta(t) + \psi(t)) \left(L_0 + \eta_1(t) + \eta_{P1}(t) \right) \right)^2 \right)^{3/2} \right) = -c_0 \left(\eta_{P1}'(t) - \eta_1'(t) \right)
\end{aligned}$$