

## DIAMAGNETIC TERMS

From Ohm's law and Faraday's law, in the direction parallel to the magnetic field,

$$E_{\parallel} = -\mathbf{b} \cdot \frac{\partial \mathbf{A}_{\parallel}}{\partial t} - \mathbf{b} \cdot \nabla \Phi = \eta J_{\parallel} - \frac{\mathbf{b} \cdot \nabla p_e}{en}, \quad (1)$$

where

$$\mathbf{A}_{\parallel} \equiv -\frac{\Psi}{R_0} \mathbf{e}^{\zeta}. \quad (2)$$

The last term in (1) is the diamagnetic contribution to the evolution equation for the poloidal flux  $\Psi$ . In dimensionless units, the equation is

$$\frac{\partial \tilde{\Psi}}{\partial t} = \sqrt{g} B \nabla_{\parallel} \Phi - \frac{\beta_{0e}}{2\varepsilon^2 \omega_{cy} n} \sqrt{g} B \nabla_{\parallel} p + \frac{\eta}{S} \tilde{J}^{\zeta}, \quad (3)$$

Here,  $\omega_{cy} = \omega_{c0} \tau_A$ , where  $\omega_{c0} = eB_0/m_i$  is the cyclotron frequency of the thermal ions.

Contribution to the momentum balance:

$$\frac{\partial U}{\partial t} = \sqrt{g} \frac{\partial}{\partial t} [\nabla \times (\rho_m \sqrt{g} \mathbf{v})]^{\zeta} = \dots - \sqrt{g} [\nabla \times (\rho_m \sqrt{g} (\mathbf{v}_{*i} \cdot \nabla) \mathbf{v}_{\perp})]^{\zeta}, \quad (4)$$

where

$$\mathbf{v}_{*i} = \frac{\mathbf{B} \times \nabla p_i}{enB^2} \quad (5)$$

For the calculation of the components of  $(\mathbf{B} \times \nabla p \cdot \nabla) \mathbf{v}_{\perp}$ , we need either the Christoffel symbols  $\Gamma_{ij}^k$  or the use of vector identities. Instead of calculating the Christoffel symbols, we get, from vector identities,

$$\begin{aligned} (\mathbf{B} \times \nabla p \cdot \nabla) \mathbf{v}_{\perp} = & \frac{1}{2} \{ \nabla [(\mathbf{B} \times \nabla p) \cdot \mathbf{v}_{\perp}] + \nabla \times [\mathbf{v}_{\perp} \times (\mathbf{B} \times \nabla p)] - (\mathbf{B} \times \nabla p) \times (\nabla \times \mathbf{v}_{\perp}) \\ & - \mathbf{v}_{\perp} \times [\nabla \times (\mathbf{B} \times \nabla p)] + \mathbf{B} \times \nabla p (\nabla \cdot \mathbf{v}_{\perp}) - \mathbf{v}_{\perp} \nabla \cdot (\mathbf{B} \times \nabla p) \} \end{aligned} \quad (6)$$

In dimensionless units,

$$\begin{aligned} (\mathbf{B} \times \nabla p)^i &= \frac{B_0 p(0)}{a} \frac{1}{\sqrt{g}} \frac{dp_{eq}}{d\rho} \left( 0, J, -\frac{I}{\varepsilon \rho} \right) \\ (\mathbf{B} \times \nabla p) \cdot \mathbf{v}_{\perp} &= \frac{B_0 p(0)}{\tau_A} \frac{dp_{eq}}{d\rho} \left[ J \left( -\frac{g_{\rho\theta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\theta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) - \frac{I}{\varepsilon \rho} \left( -\frac{g_{\rho\zeta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\zeta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) \right] \\ [\mathbf{v}_{\perp} \times (\mathbf{B} \times \nabla p)]_i &= \frac{B_0 p(0)}{\tau_A} \frac{dp_{eq}}{d\rho} \left( -\frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho}, -\frac{I}{\varepsilon \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta}, -J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) \end{aligned}$$

$$\{\nabla \times [\mathbf{v}_\perp \times (\mathbf{B} \times \nabla p)]\}^i = -\frac{B_0 p(0)}{a\tau_A} \frac{1}{\sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right), \right. \\ \left. \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) - \frac{\partial}{\partial \rho} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right), \right. \\ \left. \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( p' \frac{I}{\varepsilon} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) \right]$$

where  $p' = dp_{eq}/d\rho$ .

$$(\nabla \times \mathbf{v}_\perp)^i = \frac{1}{\tau_A} \frac{1}{\sqrt{g}} \left( \frac{1}{\rho} \frac{\partial v_\zeta}{\partial \theta} - \varepsilon \frac{\partial v_\theta}{\partial \zeta}, \varepsilon \frac{\partial v_\rho}{\partial \zeta} - \frac{\partial v_\zeta}{\partial \rho}, \frac{1}{\rho} \frac{\partial (\rho v_\theta)}{\partial \rho} - \frac{1}{\rho} \frac{\partial v_\rho}{\partial \theta} \right) \\ = \frac{1}{\tau_A} \frac{1}{\sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( -g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\theta\zeta} \frac{\partial \Phi}{\partial \rho} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( -g_{\rho\theta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\theta\theta} \frac{\partial \Phi}{\partial \rho} \right), \right. \\ \left. \varepsilon \frac{\partial}{\partial \zeta} \left( -g_{\rho\rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\rho\theta} \frac{\partial \Phi}{\partial \rho} \right) - \frac{\partial}{\partial \rho} \left( -g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\theta\zeta} \frac{\partial \Phi}{\partial \rho} \right), \right. \\ \left. \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( -\rho g_{\rho\theta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \rho g_{\theta\theta} \frac{\partial \Phi}{\partial \rho} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( -g_{\rho\rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\rho\theta} \frac{\partial \Phi}{\partial \rho} \right) \right]$$

$$[\nabla \times (\mathbf{B} \times \nabla p)]^i = \frac{B_0 p(0)}{a^2} \frac{1}{\sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\theta\zeta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\zeta\zeta}}{\sqrt{g}} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right), \right. \\ \left. \varepsilon \frac{\partial}{\partial \zeta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) - \frac{\partial}{\partial \rho} \left( p' J \frac{g_{\theta\zeta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\zeta\zeta}}{\sqrt{g}} \right), \right. \\ \left. \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right]$$

$$\nabla \cdot \mathbf{v}_\perp = \frac{1}{\tau_A} \frac{1}{\sqrt{g}} \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{\partial \Phi}{\partial \rho} \right)$$

$$\nabla \cdot (\mathbf{B} \times \nabla p) = 0$$

So, except for a factor  $B_0 p(0)/(a\tau_A)$ , the covariant components of  $\mathbf{G} = 2(\mathbf{B} \times \nabla p \cdot \nabla) \mathbf{v}_\perp$  can be written as

$$\begin{aligned}
G_\rho = & \frac{\partial}{\partial \rho} \left[ p' J \left( -\frac{g_{\rho\theta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\theta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) - p' \frac{I}{\varepsilon \rho} \left( -\frac{g_{\rho\zeta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\zeta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& - \frac{g_{\rho\rho}}{\sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) \right] \\
& - \frac{g_{\rho\theta}}{\sqrt{g}} \left[ \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) - \frac{\partial}{\partial \rho} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) \right] \\
& - \frac{g_{\rho\zeta}}{\sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( p' \frac{I}{\varepsilon} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& - \frac{p' J}{\sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( -\rho g_{\rho\theta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \rho g_{\theta\theta} \frac{\partial \Phi}{\partial \rho} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( -g_{\rho\rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\rho\theta} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& - \frac{p' I}{\varepsilon \rho \sqrt{g}} \left[ \varepsilon \frac{\partial}{\partial \zeta} \left( -g_{\rho\rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\rho\theta} \frac{\partial \Phi}{\partial \rho} \right) - \frac{\partial}{\partial \rho} \left( -g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\theta\zeta} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& - \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] \frac{\partial \Phi}{\partial \rho} \\
& + p' \left( J \frac{g_{\rho\theta}}{\sqrt{g}} - \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \frac{1}{\sqrt{g}} \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{\partial \Phi}{\partial \rho} \right)
\end{aligned}$$

$$\begin{aligned}
G_\theta = & \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ p' J \left( -\frac{g_{\rho\theta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\theta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) - p' \frac{I}{\varepsilon \rho} \left( -\frac{g_{\rho\zeta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\zeta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& - \frac{g_{\rho\theta}}{\sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) \right] \\
& - \frac{g_{\theta\theta}}{\sqrt{g}} \left[ \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) - \frac{\partial}{\partial \rho} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) \right] \\
& - \frac{g_{\theta\zeta}}{\sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( p' \frac{I}{\varepsilon} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& + \frac{p' I}{\varepsilon \rho \sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( -g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\theta\zeta} \frac{\partial \Phi}{\partial \rho} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( -g_{\rho\theta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\theta\theta} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& - \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& + p' \left( J \frac{g_{\theta\theta}}{\sqrt{g}} - \frac{I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \frac{1}{\sqrt{g}} \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{\partial \Phi}{\partial \rho} \right)
\end{aligned}$$

Then,

$$F^\zeta = 2\sqrt{g} \left[ \nabla \times \left( \frac{\sqrt{g}}{B^2} (\mathbf{B} \times \nabla p \cdot \nabla) \mathbf{v}_\perp \right) \right]^\zeta = \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho \frac{\sqrt{g}}{B^2} G_\theta \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} G_\rho \right)$$

so, except for a factor  $p(0)/(a^2 B_0 \tau_A)$ ,

$$\begin{aligned}
F^\zeta = & \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ p' J \left( -\frac{g_{\rho\theta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\theta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) - p' \frac{I}{\varepsilon \rho} \left( -\frac{g_{\rho\zeta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\zeta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left[ p' J \left( -\frac{g_{\rho\theta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\theta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) - p' \frac{I}{\varepsilon \rho} \left( -\frac{g_{\rho\zeta}}{\sqrt{g}} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{g_{\theta\zeta}}{\sqrt{g}} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \rho} \left\{ \rho \frac{g_{\rho\theta}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) \right] \right. \\
& \quad + \rho \frac{g_{\theta\theta}}{B^2} \left[ \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) - \frac{\partial}{\partial \rho} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) \right] \\
& \quad \left. + \rho \frac{g_{\theta\zeta}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( p' \frac{I}{\varepsilon} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) \right] \right\} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left\{ \frac{g_{\rho\rho}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) \right] \right. \\
& \quad + \frac{g_{\rho\theta}}{B^2} \left[ \varepsilon \frac{\partial}{\partial \zeta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) - \frac{\partial}{\partial \rho} \left( p' J \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) \right] \\
& \quad \left. + \frac{g_{\rho\zeta}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( p' \frac{I}{\varepsilon} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' \frac{I}{\varepsilon \rho} \frac{\partial \Phi}{\partial \rho} \right) \right] \right\} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left\{ \frac{p' J}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( -\rho g_{\rho\theta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \rho g_{\theta\theta} \frac{\partial \Phi}{\partial \rho} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( -g_{\rho\rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\rho\theta} \frac{\partial \Phi}{\partial \rho} \right) \right] \right\} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left\{ \frac{p' I}{\varepsilon B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( -g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\theta\zeta} \frac{\partial \Phi}{\partial \rho} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( -g_{\rho\theta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\theta\theta} \frac{\partial \Phi}{\partial \rho} \right) \right] \right\} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left\{ \frac{p' I}{\varepsilon \rho B^2} \left[ \varepsilon \frac{\partial}{\partial \zeta} \left( -g_{\rho\rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\rho\theta} \frac{\partial \Phi}{\partial \rho} \right) - \frac{\partial}{\partial \rho} \left( -g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + g_{\theta\zeta} \frac{\partial \Phi}{\partial \rho} \right) \right] \right\} \\
& - \frac{\partial}{\partial \rho} \left\{ \frac{\sqrt{g}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] \right\} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left\{ \frac{\sqrt{g}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] \right\} \frac{\partial \Phi}{\partial \rho} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left[ p' \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \frac{1}{\sqrt{g} B^2} \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{\partial \Phi}{\partial \theta} + \frac{\partial \sqrt{g}}{\partial \theta} \frac{\partial \Phi}{\partial \rho} \right) \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ p' \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \frac{1}{\sqrt{g} B^2} \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{\partial \Phi}{\partial \rho} \right) \right]
\end{aligned}$$

$$\begin{aligned}
F^\zeta = & \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ - \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - \frac{p' I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \left( p' J \frac{g_{\theta\theta}}{\sqrt{g}} - \frac{p' I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \frac{\partial \Phi}{\partial \rho} \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left[ - \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - \frac{p' I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \left( p' J \frac{g_{\theta\theta}}{\sqrt{g}} - \frac{p' I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \frac{\partial \Phi}{\partial \rho} \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \rho} \left[ \rho \frac{g_{\rho\theta}}{B^2} \left( p' J \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} - \frac{p' I}{\rho} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} \right) + \rho \frac{g_{\theta\theta}}{B^2} \left( \frac{p' I}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} - p' J \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \right) \right. \\
& \quad \left. - \rho \frac{g_{\theta\theta}}{B^2} \left( \frac{p' J}{\rho} \right)' \frac{\partial \Phi}{\partial \theta} + \rho \frac{g_{\theta\zeta}}{\varepsilon B^2} \left( \frac{p' I}{\rho} \right)' \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right] \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{g_{\rho\rho}}{B^2} \left( p' J \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} - \frac{p' I}{\rho} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} \right) + \frac{g_{\rho\theta}}{B^2} \left( \frac{p' I}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} - p' J \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \right) \right. \\
& \quad \left. - \frac{g_{\rho\theta}}{B^2} \left( \frac{p' J}{\rho} \right)' \frac{\partial \Phi}{\partial \theta} + \frac{g_{\rho\zeta}}{\varepsilon B^2} \left( \frac{p' I}{\rho} \right)' \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right] \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left\{ \frac{p' J}{B^2} \left[ g_{\rho\rho} \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} - 2g_{\rho\theta} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + g_{\theta\theta} \frac{\partial^2 \Phi}{\partial \rho^2} \right. \right. \\
& \quad \left. \left. - \left( \frac{\partial g_{\rho\theta}}{\partial \rho} - \frac{1}{\rho} \frac{\partial g_{\rho\rho}}{\partial \theta} \right) \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \left( \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho g_{\theta\theta}) - \frac{1}{\rho} \frac{\partial g_{\rho\theta}}{\partial \theta} \right) \frac{\partial \Phi}{\partial \rho} \right] \right\} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left\{ \frac{p' I}{B^2} \left[ -\frac{g_{\rho\zeta}}{\varepsilon} \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} + \frac{g_{\theta\zeta}}{\varepsilon} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + g_{\rho\theta} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} - g_{\theta\theta} \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} \right. \right. \\
& \quad \left. \left. - \left( \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\rho\zeta}}{\partial \theta} - \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \left( \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\theta\zeta}}{\partial \theta} - \frac{\partial g_{\theta\theta}}{\partial \zeta} \right) \frac{\partial \Phi}{\partial \rho} \right] \right\} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left\{ \frac{p' I}{\rho B^2} \left[ -g_{\rho\rho} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} + g_{\rho\theta} \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} + \frac{g_{\rho\zeta}}{\varepsilon} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} - \frac{g_{\theta\zeta}}{\varepsilon} \frac{\partial^2 \Phi}{\partial \rho^2} \right. \right. \\
& \quad \left. \left. - \left( \frac{\partial g_{\rho\rho}}{\partial \zeta} - \frac{\rho}{\varepsilon} \frac{\partial}{\partial \rho} \left( \frac{g_{\rho\zeta}}{\rho} \right) \right) \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \left( \frac{\partial g_{\rho\theta}}{\partial \zeta} - \frac{1}{\varepsilon} \frac{\partial g_{\theta\zeta}}{\partial \rho} \right) \frac{\partial \Phi}{\partial \rho} \right] \right\} \\
& - \frac{\partial}{\partial \rho} \left\{ \frac{\sqrt{g}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] \right\} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left\{ \frac{\sqrt{g}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] \right\} \frac{\partial \Phi}{\partial \rho} \\
& + \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{\partial^2 \Phi}{\partial \rho^2} \right) \\
& - \frac{\partial}{\partial \rho} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \frac{\partial \sqrt{g}}{\partial \rho} \right] \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \frac{\partial \sqrt{g}}{\partial \theta} \right] \frac{\partial \Phi}{\partial \rho} \\
& - \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \right) \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \frac{\partial \sqrt{g}}{\partial \rho} \right] \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \right] \frac{\partial \Phi}{\partial \rho}
\end{aligned}$$

[illegible]

$$\begin{aligned}
& + \frac{p'I}{\rho B^2} \left[ -g_{\rho\rho} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \theta^2 \partial \zeta} + g_{\rho\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho \partial \theta \partial \zeta} + \frac{g_{\rho\zeta}}{\varepsilon} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \rho \partial \theta^2} - \frac{g_{\theta\zeta}}{\varepsilon} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \theta} \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\rho} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\theta} \right) \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{g_{\rho\zeta}}{\varepsilon} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{g_{\theta\zeta}}{\varepsilon} \right) \frac{\partial^2 \Phi}{\partial \rho^2} - \frac{p'I}{\rho B^2} \left[ \left( \frac{\partial g_{\rho\rho}}{\partial \zeta} - \frac{\rho}{\varepsilon} \frac{\partial}{\partial \rho} \left( \frac{g_{\rho\zeta}}{\rho} \right) \right) \frac{1}{\rho^2} \frac{\partial \Phi}{\partial \theta^2} - \left( \frac{\partial g_{\rho\theta}}{\partial \zeta} - \frac{1}{\varepsilon} \frac{\partial g_{\theta\zeta}}{\partial \rho} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'I}{\rho B^2} \left( \frac{\partial g_{\rho\rho}}{\partial \zeta} - \frac{\rho}{\varepsilon} \frac{\partial}{\partial \rho} \left( \frac{g_{\rho\zeta}}{\rho} \right) \right) \right] \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'I}{\rho B^2} \left( \frac{\partial g_{\rho\theta}}{\partial \zeta} - \frac{1}{\varepsilon} \frac{\partial g_{\theta\zeta}}{\partial \rho} \right) \right] \frac{\partial \Phi}{\partial \rho} \\
& - \frac{\partial}{\partial \rho} \left\{ \frac{\sqrt{g}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] \right\} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left\{ \frac{\sqrt{g}}{B^2} \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] \right\} \frac{\partial \Phi}{\partial \rho} \\
& + \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{\partial^2 \Phi}{\partial \rho^2} \right) \\
& - \frac{\partial}{\partial \rho} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \frac{\partial \sqrt{g}}{\partial \rho} \right] \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \frac{\partial \sqrt{g}}{\partial \theta} \right] \frac{\partial \Phi}{\partial \rho} \\
& - \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \right) \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \frac{\partial \sqrt{g}}{\partial \rho} \right] \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \right] \frac{\partial \Phi}{\partial \rho}
\end{aligned}$$

$$\begin{aligned}
F^\zeta = & -\frac{g_{\rho\theta}}{B^2} \left( p'J \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \rho \partial \theta^2} - \frac{p'I}{\rho} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho \partial \theta \partial \zeta} \right) - \frac{g_{\theta\theta}}{B^2} \left( \frac{p'I}{\rho} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \zeta} - p'J \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \theta} \right) \\
& + \frac{g_{\rho\rho}}{B^2} \left( p'J \frac{1}{\rho^3} \frac{\partial^3 \Phi}{\partial \theta^3} - \frac{p'I}{\rho} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \theta^2 \partial \zeta} \right) + \frac{g_{\rho\theta}}{B^2} \left( \frac{p'I}{\rho} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho \partial \theta \partial \zeta} - p'J \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \rho \partial \theta^2} \right) \\
& + \frac{p'J}{B^2} \left[ g_{\rho\rho} \frac{1}{\rho^3} \frac{\partial^3 \Phi}{\partial \theta^3} - 2g_{\rho\theta} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \rho \partial \theta^2} + g_{\theta\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \theta} \right] \\
& + \frac{p'I}{\rho B^2} \left[ -\frac{g_{\rho\zeta}}{\varepsilon} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \rho \partial \theta^2} + \frac{g_{\theta\zeta}}{\varepsilon} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \theta} + g_{\rho\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho \partial \theta \partial \zeta} - g_{\theta\theta} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \zeta} \right] \\
& + \frac{p'I}{\rho B^2} \left[ -g_{\rho\rho} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \theta^2 \partial \zeta} + g_{\rho\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho \partial \theta \partial \zeta} + \frac{g_{\rho\zeta}}{\varepsilon} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \rho \partial \theta^2} - \frac{g_{\theta\zeta}}{\varepsilon} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \theta} \right] \\
& + \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \left[ -\left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} - \frac{p'I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} + \left( p'J \frac{g_{\theta\theta}}{\sqrt{g}} - \frac{p'I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \left[ -\left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} - \frac{p'I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + \left( p'J \frac{g_{\theta\theta}}{\sqrt{g}} - \frac{p'I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \frac{\partial^2 \Phi}{\partial \rho^2} \right] \\
& - \frac{\partial}{\partial \rho} \left( \frac{p'J}{\rho} \frac{g_{\rho\theta}}{B^2} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta^2} + \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho} \frac{g_{\rho\theta}}{B^2} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} - \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( p'I \frac{g_{\theta\theta}}{B^2} \right) \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} \\
& + \frac{\partial}{\partial \rho} \left( p'J \frac{g_{\theta\theta}}{B^2} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + \left[ \rho \left( \frac{p'J}{\rho} \right)' \frac{g_{\theta\theta}}{B^2} - \left( \frac{p'I}{\rho} \right)' \frac{g_{\theta\zeta}}{\varepsilon B^2} \right] \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\rho\rho}}{B^2} \right) \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho} \frac{g_{\rho\rho}}{B^2} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho} \frac{g_{\rho\theta}}{B^2} \right) \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\rho\theta}}{B^2} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} - \left[ \rho \left( \frac{p'J}{\rho} \right)' \frac{g_{\rho\theta}}{B^2} - \left( \frac{p'I}{\rho} \right)' \frac{g_{\rho\zeta}}{\varepsilon B^2} \right] \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} \right) \left[ g_{\rho\rho} \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} - 2g_{\rho\theta} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + g_{\theta\theta} \frac{\partial^2 \Phi}{\partial \rho^2} \right] \\
& - \frac{p'J}{B^2} \left[ \left( \frac{\partial g_{\rho\theta}}{\partial \rho} - \frac{1}{\rho} \frac{\partial g_{\rho\rho}}{\partial \theta} \right) \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} - \left( \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho g_{\theta\theta}) - \frac{1}{\rho} \frac{\partial g_{\rho\theta}}{\partial \theta} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \right] \\
& - \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho^2 B^2} \frac{g_{\rho\zeta}}{\varepsilon} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta^2} + \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho B^2} \frac{g_{\theta\zeta}}{\varepsilon} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho B^2} g_{\rho\theta} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} \\
& - \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p'I}{B^2} g_{\theta\theta} \right) \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} - \frac{p'I}{\rho B^2} \left[ \left( \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\rho\zeta}}{\partial \theta} - \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} - \left( \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\theta\zeta}}{\partial \theta} - \frac{\partial g_{\theta\theta}}{\partial \zeta} \right) \frac{\partial^2 \Phi}{\partial \rho^2} \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\rho} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\theta} \right) \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{g_{\rho\zeta}}{\varepsilon} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{g_{\theta\zeta}}{\varepsilon} \right) \frac{\partial^2 \Phi}{\partial \rho^2} - \frac{p'I}{\rho B^2} \left[ \left( \frac{\partial g_{\rho\rho}}{\partial \zeta} - \frac{\rho}{\varepsilon} \frac{\partial}{\partial \rho} \left( \frac{g_{\rho\zeta}}{\rho} \right) \right) \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} - \left( \frac{\partial g_{\rho\theta}}{\partial \zeta} - \frac{1}{\varepsilon} \frac{\partial g_{\theta\zeta}}{\partial \rho} \right) \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \right] \\
& + \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{\partial^2 \Phi}{\partial \rho^2} \right) \\
& - \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \left( -\frac{\partial \sqrt{g}}{\partial \rho} \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} + \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \right)
\end{aligned}$$



$$\begin{aligned}
& + \left\{ -\frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - \frac{p' I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) + \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( \frac{p' J}{\rho} \frac{g_{\rho\theta}}{\sqrt{g}} - \frac{p' I}{\varepsilon \rho^2} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right. \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \rho \left( \frac{p' J}{\rho} \right)' \frac{g_{\rho\theta}}{B^2} - \left( \frac{p' I}{\rho} \right)' \frac{g_{\rho\zeta}}{\varepsilon B^2} \right] + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \frac{\partial \sqrt{g}}{\partial \rho} \right] \\
& + \frac{\partial}{\partial \rho} \left[ \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p' J}{B^2} \left( \frac{\partial g_{\rho\theta}}{\partial \rho} - \frac{1}{\rho} \frac{\partial g_{\rho\rho}}{\partial \theta} \right) \right] \\
& - \frac{\partial}{\partial \rho} \left[ \frac{p' I}{\rho B^2} \left( \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\rho\zeta}}{\partial \theta} - \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) \right] - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p' I}{\rho B^2} \left( \frac{\partial g_{\rho\rho}}{\partial \zeta} - \frac{\rho}{\varepsilon} \frac{\partial}{\partial \rho} \left( \frac{g_{\rho\zeta}}{\rho} \right) \right) \right] \\
& + \frac{\partial}{\partial \rho} \left[ \rho \left( \frac{p' J}{\rho} \right)' \frac{g_{\theta\theta}}{B^2} - \left( \frac{p' I}{\rho} \right)' \frac{g_{\theta\zeta}}{\varepsilon B^2} \right] - \frac{\partial}{\partial \rho} \left[ \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \right] \\
& - \frac{\partial}{\partial \rho} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \frac{\partial \sqrt{g}}{\partial \rho} \right] \left\} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right. \\
& + \left\{ \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\theta\theta}}{\sqrt{g}} - \frac{p' I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( p' J \frac{g_{\theta\theta}}{\sqrt{g}} - \frac{p' I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \right. \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \right] + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \frac{\partial \sqrt{g}}{\partial \theta} \right] \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p' J}{B^2} \left( \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho g_{\theta\theta}) - \frac{1}{\rho} \frac{\partial g_{\rho\theta}}{\partial \theta} \right) \right] + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left[ \frac{p' I}{B^2} \left( \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\theta\zeta}}{\partial \theta} - \frac{\partial g_{\theta\theta}}{\partial \zeta} \right) \right] \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p' I}{\rho B^2} \left( \frac{\partial g_{\rho\theta}}{\partial \zeta} - \frac{1}{\varepsilon} \frac{\partial g_{\theta\zeta}}{\partial \rho} \right) \right] - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} - p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \right] \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \right] \left\} \frac{\partial \Phi}{\partial \rho}
\end{aligned}$$

$$\begin{aligned}
F^\zeta = & 2 \frac{p'J}{B^2} \left( g_{\rho\rho} \frac{1}{\rho^3} \frac{\partial^3 \Phi}{\partial \theta^3} - 2g_{\rho\theta} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \rho \partial \theta^2} + g_{\theta\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \theta} \right) \\
& - 2 \frac{p'I}{\rho B^2} \left( g_{\rho\rho} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \theta^2 \partial \zeta} - 2g_{\rho\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho \partial \theta \partial \zeta} + g_{\theta\theta} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \zeta} \right) \\
& + \left[ -\frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} - \frac{p'I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) - \rho \frac{\partial}{\partial \rho} \left( \frac{p'J}{\rho} \frac{g_{\rho\theta}}{B^2} \right) + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\rho\rho}}{B^2} \right) - \rho \left( \frac{p'J}{\rho} \right)' \frac{g_{\rho\theta}}{B^2} \right. \\
& + \left( \frac{p'I}{\rho} \right)' \frac{g_{\rho\zeta}}{\varepsilon B^2} + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} \right) g_{\rho\rho} - \frac{p'J}{B^2} \left( \frac{\partial g_{\rho\theta}}{\partial \rho} - \frac{1}{\rho} \frac{\partial g_{\rho\rho}}{\partial \theta} \right) - \rho \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho^2 B^2} \frac{g_{\rho\zeta}}{\varepsilon} \right) \\
& - \frac{p'I}{\rho B^2} \left( \frac{\partial g_{\rho\rho}}{\partial \zeta} - \frac{\rho}{\varepsilon} \frac{\partial}{\partial \rho} \left( \frac{g_{\rho\zeta}}{\rho} \right) \right) + \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \frac{\partial \sqrt{g}}{\partial \rho} \left. \right] \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} \\
& + \left[ \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \left( p'J \frac{g_{\theta\theta}}{\sqrt{g}} - \frac{p'I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} - \frac{p'I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) + \frac{\partial}{\partial \rho} \left( p'J \frac{g_{\theta\theta}}{B^2} \right) \right. \\
& + \rho \left( \frac{p'J}{\rho} \right)' \frac{g_{\theta\theta}}{B^2} - \left( \frac{p'I}{\rho} \right)' \frac{g_{\theta\zeta}}{\varepsilon B^2} - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\rho\theta}}{B^2} \right) - \frac{2}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} \right) g_{\rho\theta} \\
& + \frac{p'J}{B^2} \left( \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho g_{\theta\theta}) - \frac{1}{\rho} \frac{\partial g_{\rho\theta}}{\partial \theta} \right) + \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho B^2} \frac{g_{\theta\zeta}}{\varepsilon} \right) - \frac{p'I}{\rho B^2} \left( \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\rho\zeta}}{\partial \theta} - \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{g_{\rho\zeta}}{\varepsilon} \right) + \frac{p'I}{\rho B^2} \left( \frac{\partial g_{\rho\theta}}{\partial \zeta} - \frac{1}{\varepsilon} \frac{\partial g_{\theta\zeta}}{\partial \rho} \right) - \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \frac{\partial \sqrt{g}}{\partial \rho} \\
& - \frac{p'}{\sqrt{g} B^2} \left( J g_{\rho\theta} - \frac{I}{\varepsilon \rho} g_{\rho\zeta} \right) \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \left. \right] \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \\
& + \left[ -\frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \left( p'J \frac{g_{\theta\theta}}{\sqrt{g}} - \frac{p'I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} \right) g_{\theta\theta} + \frac{p'I}{\rho B^2} \left( \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\theta\zeta}}{\partial \theta} - \frac{\partial g_{\theta\theta}}{\partial \zeta} \right) \right. \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{g_{\theta\zeta}}{\varepsilon} \right) + \frac{p'}{\sqrt{g} B^2} \left( J g_{\theta\theta} - \frac{I}{\varepsilon \rho} g_{\theta\zeta} \right) \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \left. \right] \frac{\partial^2 \Phi}{\partial \rho^2} \\
& + 2 \left[ \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho B^2} g_{\rho\theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\rho} \right) \right] \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} \\
& - 2 \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p'I}{B^2} g_{\theta\theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\theta} \right) \right] \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} \\
& + \left\{ -\frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} \right) + \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( \frac{p'J}{\rho} \frac{g_{\rho\theta}}{\sqrt{g}} \right) \right. \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \rho \left( \frac{p'J}{\rho} \right)' \frac{g_{\rho\theta}}{B^2} + \sqrt{g} \frac{p'J}{B^2} g_{\rho\theta} \frac{\partial}{\partial \rho} \left( \frac{1}{\sqrt{g}} \right) + \frac{p'J}{B^2} \frac{\partial g_{\rho\theta}}{\partial \rho} \right] \\
& + \frac{\partial}{\partial \rho} \left[ \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} \right) \right] + \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho B^2} \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{\partial g_{\rho\rho}}{\partial \zeta} \right) \\
& + \frac{\partial}{\partial \rho} \left[ \rho \left( \frac{p'J}{\rho} \right)' \frac{g_{\theta\theta}}{B^2} - \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p'J \frac{g_{\theta\theta}}{\sqrt{g}} \right) - \frac{p'}{\sqrt{g} B^2} J g_{\theta\theta} \frac{\partial \sqrt{g}}{\partial \rho} \right]
\end{aligned}$$

$$\begin{aligned}
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p' J}{B^2} \frac{1}{\rho} \frac{\partial g_{\rho\rho}}{\partial \theta} \right) + \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p' I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) - \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( \frac{p' I}{\varepsilon \rho^2} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \left( \frac{p' I}{\rho} \right)' \frac{g_{\rho\zeta}}{\varepsilon B^2} + \frac{\sqrt{g} p' I}{B^2 \varepsilon \rho} g_{\rho\zeta} \frac{\partial}{\partial \rho} \left( \frac{1}{\sqrt{g}} \right) + \frac{p' I}{\rho B^2} \frac{\rho}{\varepsilon} \frac{\partial}{\partial \rho} \left( \frac{g_{\rho\zeta}}{\rho} \right) \right] \\
& - \frac{\partial}{\partial \rho} \left[ \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) + \frac{p' I}{\rho B^2} \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\rho\zeta}}{\partial \theta} \right] \\
& - \frac{\partial}{\partial \rho} \left[ \left( \frac{p' I}{\rho} \right)' \frac{g_{\theta\zeta}}{\varepsilon B^2} + \frac{\sqrt{g} p' I}{B^2 \varepsilon \rho} g_{\theta\zeta} \frac{\partial}{\partial \rho} \left( \frac{1}{\sqrt{g}} \right) - \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \right] \left\} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \right. \\
& + \left\{ \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\theta\theta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( p' J \frac{g_{\theta\theta}}{\sqrt{g}} \right) \right. \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p' J}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho g_{\theta\theta}) + \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho p' J \frac{g_{\theta\theta}}{\sqrt{g}} \right) \right] + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p'}{\sqrt{g} B^2} J g_{\theta\theta} \frac{\partial \sqrt{g}}{\partial \theta} \right) \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p' J}{B^2} \frac{1}{\rho} \frac{\partial g_{\rho\theta}}{\partial \theta} + \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' J \frac{g_{\rho\theta}}{\sqrt{g}} \right) + \frac{p'}{\sqrt{g} B^2} J g_{\rho\theta} \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \right] \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p' I}{\rho B^2} \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p' I}{B^2} \frac{\partial g_{\theta\theta}}{\partial \zeta} \right) \\
& - \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p' I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( \frac{p' I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \\
& + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p' I}{B^2} \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\theta\zeta}}{\partial \theta} - \frac{p'}{\sqrt{g} B^2} \frac{I}{\varepsilon \rho} g_{\theta\zeta} \frac{\partial \sqrt{g}}{\partial \theta} \right) \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) + \frac{p' I}{\rho B^2} \frac{1}{\varepsilon} \frac{\partial g_{\theta\zeta}}{\partial \rho} \right] \\
& \left. + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p' \frac{I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) + \frac{p'}{\sqrt{g} B^2} \frac{I}{\varepsilon \rho} g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \sqrt{g}}{\partial \theta} \right] \right\} \frac{\partial \Phi}{\partial \rho}
\end{aligned}$$

$$\begin{aligned}
F^\zeta = & 2 \frac{p'J}{B^2} \left( g_{\rho\rho} \frac{1}{\rho^3} \frac{\partial^3 \Phi}{\partial \theta^3} - 2g_{\rho\theta} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \rho \partial \theta^2} + g_{\theta\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \theta} \right) \\
& - 2 \frac{p'I}{\rho B^2} \left( g_{\rho\rho} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \theta^2 \partial \zeta} - 2g_{\rho\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho \partial \theta \partial \zeta} + g_{\theta\theta} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \zeta} \right) \\
& + 2 \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} g_{\rho\rho} \right) - \rho \frac{\partial}{\partial \rho} \left( \frac{p'J}{\rho B^2} g_{\rho\theta} \right) \right] \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} \\
& + 2 \left[ \frac{\partial}{\partial \rho} \left( \frac{p'J}{B^2} g_{\theta\theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} g_{\rho\theta} \right) \right] \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \\
& - \frac{p'I}{\rho B^2} \left( \frac{\partial g_{\rho\rho}}{\partial \zeta} \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} - 2 \frac{\partial g_{\rho\theta}}{\partial \zeta} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + \frac{\partial g_{\theta\theta}}{\partial \zeta} \frac{\partial^2 \Phi}{\partial \rho^2} \right) \\
& + 2 \left[ \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho B^2} g_{\rho\theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\rho} \right) \right] \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} \\
& - 2 \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p'I}{B^2} g_{\theta\theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\theta} \right) \right] \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} \\
& + \left\{ -\frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} \right) + \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( \frac{p'J}{\rho} \frac{g_{\rho\theta}}{\sqrt{g}} \right) + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{\rho} \frac{g_{\rho\theta}}{B^2} \right) \right. \\
& - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{\sqrt{g}}{B^2} \frac{\partial}{\partial \rho} \left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} \right) \right] - \frac{\sqrt{g}}{B^2} \frac{1}{\rho^2} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} \right) + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left[ \frac{\sqrt{g}}{B^2} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\rho\theta}}{\sqrt{g}} \right) \right] \\
& + \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho B^2} \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{\partial g_{\rho\rho}}{\partial \zeta} \right) - \frac{\partial}{\partial \rho} \left( 2 \frac{p'J}{\rho} \frac{g_{\theta\theta}}{B^2} + \frac{p'J}{B^2} \frac{\partial g_{\theta\theta}}{\partial \rho} \right) \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} \frac{1}{\rho} \frac{\partial g_{\rho\rho}}{\partial \theta} \right) + \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) - \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( \frac{p'I}{\varepsilon \rho^2} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{\sqrt{g}}{B^2} \frac{\partial}{\partial \rho} \left( \frac{p'I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) - \frac{p'I}{\rho^2 B^2} \frac{g_{\rho\zeta}}{\varepsilon} \right] - \frac{\partial}{\partial \rho} \left[ \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\varepsilon \rho} \frac{g_{\rho\zeta}}{\sqrt{g}} \right) + \frac{p'I}{\rho B^2} \frac{1}{\varepsilon} \frac{1}{\rho} \frac{\partial g_{\rho\zeta}}{\partial \theta} \right] \\
& - \frac{\partial}{\partial \rho} \left[ \frac{\sqrt{g}}{B^2} \frac{\partial}{\partial \rho} \left( \frac{p'I}{\varepsilon \rho} \frac{1}{\sqrt{g}} \right) g_{\theta\zeta} - \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( p' \frac{I}{\varepsilon} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \right] \left. \right\} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& + \left\{ \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( p'J \frac{g_{\theta\theta}}{\sqrt{g}} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( p'J \frac{g_{\theta\theta}}{\sqrt{g}} \right) \right. \\
& + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'J}{B^2} \frac{\partial g_{\theta\theta}}{\partial \rho} + \frac{\sqrt{g}}{B^2} \frac{\partial}{\partial \rho} \left( p'J \frac{g_{\theta\theta}}{\sqrt{g}} \right) + 2 \frac{p'J}{\rho B^2} g_{\theta\theta} \right] + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p'J}{B^2} \frac{g_{\theta\theta}}{\sqrt{g}} \frac{\partial \sqrt{g}}{\partial \theta} \right) \\
& - \frac{2}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} \frac{1}{\rho} \frac{\partial g_{\rho\theta}}{\partial \theta} \right) + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p'I}{B^2} \frac{\partial g_{\theta\theta}}{\partial \zeta} \right) \\
& - \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\sqrt{g}}{B^2} \right) \frac{\partial}{\partial \rho} \left( \frac{p'I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \\
& + \frac{1}{\rho} \frac{\partial}{\partial \rho} \left[ \frac{\sqrt{g}}{B^2} \frac{p'I}{\varepsilon \rho} \frac{\partial}{\partial \theta} \left( \frac{g_{\theta\zeta}}{\sqrt{g}} \right) \right] - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{\sqrt{g}}{B^2} \frac{\partial}{\partial \rho} \left( \frac{p'I}{\varepsilon \rho} \frac{g_{\theta\zeta}}{\sqrt{g}} \right) + \frac{p'I}{\varepsilon \rho B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho g_{\theta\zeta}) \right] \\
& + \left. \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'I}{\varepsilon \rho B^2} \frac{1}{\rho} \frac{\partial g_{\rho\zeta}}{\partial \theta} \right] \right\} \frac{\partial \Phi}{\partial \rho}
\end{aligned}$$

$$\begin{aligned}
F^\zeta = & 2 \frac{p'J}{B^2} \left( g_{\rho\rho} \frac{1}{\rho^3} \frac{\partial^3 \Phi}{\partial \theta^3} - 2g_{\rho\theta} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \rho \partial \theta^2} + g_{\theta\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \theta} \right) \\
& - 2 \frac{p'I}{\rho B^2} \left( g_{\rho\rho} \frac{1}{\rho^2} \frac{\partial^3 \Phi}{\partial \theta^2 \partial \zeta} - 2g_{\rho\theta} \frac{1}{\rho} \frac{\partial^3 \Phi}{\partial \rho \partial \theta \partial \zeta} + g_{\theta\theta} \frac{\partial^3 \Phi}{\partial \rho^2 \partial \zeta} \right) \\
& + 2 \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} g_{\rho\rho} \right) - \rho \frac{\partial}{\partial \rho} \left( \frac{p'J}{\rho B^2} g_{\rho\theta} \right) \right] \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} \\
& + 2 \left[ \frac{\partial}{\partial \rho} \left( \frac{p'J}{B^2} g_{\theta\theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} g_{\rho\theta} \right) \right] \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} \\
& - \frac{p'I}{\rho B^2} \left( \frac{\partial g_{\rho\rho}}{\partial \zeta} \frac{1}{\rho^2} \frac{\partial^2 \Phi}{\partial \theta^2} - 2 \frac{\partial g_{\rho\theta}}{\partial \zeta} \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \rho \partial \theta} + \frac{\partial g_{\theta\theta}}{\partial \zeta} \frac{\partial^2 \Phi}{\partial \rho^2} \right) \\
& + 2 \left[ \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho B^2} g_{\rho\theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\rho} \right) \right] \frac{1}{\rho} \frac{\partial^2 \Phi}{\partial \theta \partial \zeta} \\
& - 2 \left[ \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p'I}{B^2} g_{\theta\theta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} g_{\rho\theta} \right) \right] \frac{\partial^2 \Phi}{\partial \rho \partial \zeta} \\
& + \left\{ - \frac{\partial}{\partial \rho} \left[ \frac{p'J}{\rho^2 B^2} \frac{\partial}{\partial \rho} (\rho^2 g_{\theta\theta}) \right] + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} \frac{1}{\rho} \frac{\partial g_{\rho\rho}}{\partial \theta} \right) + \frac{\partial}{\partial \rho} \left( \frac{p'I}{\rho B^2} \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) \right. \\
& \quad \left. - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{\partial g_{\rho\rho}}{\partial \zeta} \right) - \frac{\partial}{\partial \rho} \left( \frac{p'I}{\varepsilon \rho B^2} \frac{1}{\rho} \frac{\partial g_{\rho\zeta}}{\partial \theta} \right) + \frac{\partial}{\partial \rho} \left[ \frac{p'I}{\varepsilon \rho B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho g_{\theta\zeta}) \right] \right\} \frac{1}{\rho} \frac{\partial \Phi}{\partial \theta} \\
& + \left\{ p'J \frac{\partial}{\partial \rho} \left( \frac{\sqrt{g}}{B^2} \right) \frac{1}{\rho} \frac{\partial g_{\theta\theta}}{\partial \theta} - \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} \left[ p'J g_{\theta\theta} \frac{\partial}{\partial \theta} \left( \frac{1}{\sqrt{g}} \right) \right] \right. \\
& \quad \left. + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} \frac{\partial g_{\theta\theta}}{\partial \rho} + 2 \frac{p'J}{\rho B^2} g_{\theta\theta} \right) + \frac{\sqrt{g}}{B^2} \frac{1}{\rho} \frac{\partial^2}{\partial \rho \partial \theta} \left( p'J \frac{g_{\theta\theta}}{\sqrt{g}} \right) \right. \\
& \quad \left. - \frac{2}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'J}{B^2} \frac{1}{\rho} \frac{\partial g_{\rho\theta}}{\partial \theta} \right) + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{p'I}{\rho B^2} \frac{\partial g_{\rho\theta}}{\partial \zeta} \right) - \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \frac{p'I}{B^2} \frac{\partial g_{\theta\theta}}{\partial \zeta} \right) \right. \\
& \quad \left. - \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'I}{\varepsilon \rho B^2} \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho g_{\theta\zeta}) \right] + \frac{1}{\rho} \frac{\partial}{\partial \theta} \left[ \frac{p'I}{\varepsilon \rho B^2} \frac{1}{\rho} \frac{\partial g_{\rho\zeta}}{\partial \theta} \right] \right\} \frac{\partial \Phi}{\partial \rho}
\end{aligned}$$

Finally, we get that, in dimensionless units,

$$\frac{\partial U}{\partial t} = \dots - \frac{\beta_{0i}}{2\varepsilon^2\omega_{cy}}\sqrt{g}\left[\nabla \times \left(\frac{\sqrt{g}}{B^2}(\mathbf{B} \times \nabla p \cdot \nabla)\mathbf{v}_\perp\right)\right]^\zeta \quad (7)$$

where

$$\begin{aligned} & \sqrt{g}\left[\nabla \times \left(\frac{\sqrt{g}}{B^2}(\mathbf{B} \times \nabla p \cdot \nabla)\mathbf{v}_\perp\right)\right]^\zeta = \\ & \frac{p'J}{B^2}\left(g_{\rho\rho}\frac{1}{\rho^3}\frac{\partial^3\Phi}{\partial\theta^3} - 2g_{\rho\theta}\frac{1}{\rho^2}\frac{\partial^3\Phi}{\partial\rho\partial\theta^2} + g_{\theta\theta}\frac{1}{\rho}\frac{\partial^3\Phi}{\partial\rho^2\partial\theta}\right) \\ & - \frac{p'I}{\rho B^2}\left(g_{\rho\rho}\frac{1}{\rho^2}\frac{\partial^3\Phi}{\partial\theta^2\partial\zeta} - 2g_{\rho\theta}\frac{1}{\rho}\frac{\partial^3\Phi}{\partial\rho\partial\theta\partial\zeta} + g_{\theta\theta}\frac{\partial^3\Phi}{\partial\rho^2\partial\zeta}\right) \\ & + \left[\frac{1}{\rho}\frac{\partial}{\partial\theta}\left(\frac{p'J}{B^2}g_{\rho\rho}\right) - \rho\frac{\partial}{\partial\rho}\left(\frac{p'J}{\rho B^2}g_{\rho\theta}\right)\right]\frac{1}{\rho^2}\frac{\partial^2\Phi}{\partial\theta^2} \\ & + \left[\frac{\partial}{\partial\rho}\left(\frac{p'J}{B^2}g_{\theta\theta}\right) - \frac{1}{\rho}\frac{\partial}{\partial\theta}\left(\frac{p'J}{B^2}g_{\rho\theta}\right)\right]\frac{1}{\rho}\frac{\partial^2\Phi}{\partial\rho\partial\theta} \\ & - \frac{1}{2}\frac{p'I}{\rho B^2}\left(\frac{\partial g_{\rho\rho}}{\partial\zeta}\frac{1}{\rho^2}\frac{\partial^2\Phi}{\partial\theta^2} - 2\frac{\partial g_{\rho\theta}}{\partial\zeta}\frac{1}{\rho}\frac{\partial^2\Phi}{\partial\rho\partial\theta} + \frac{\partial g_{\theta\theta}}{\partial\zeta}\frac{\partial^2\Phi}{\partial\rho^2}\right) \\ & + \left[\frac{\partial}{\partial\rho}\left(\frac{p'I}{\rho B^2}g_{\rho\theta}\right) - \frac{1}{\rho}\frac{\partial}{\partial\theta}\left(\frac{p'I}{\rho B^2}g_{\rho\rho}\right)\right]\frac{1}{\rho}\frac{\partial^2\Phi}{\partial\theta\partial\zeta} \\ & - \left[\frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\frac{p'I}{B^2}g_{\theta\theta}\right) - \frac{1}{\rho}\frac{\partial}{\partial\theta}\left(\frac{p'I}{\rho B^2}g_{\rho\theta}\right)\right]\frac{\partial^2\Phi}{\partial\rho\partial\zeta} \\ & + \frac{1}{2}\left\{\frac{1}{\rho}\frac{\partial}{\partial\theta}\left(\frac{p'J}{B^2}\frac{1}{\rho}\frac{\partial g_{\rho\rho}}{\partial\theta}\right) - \frac{\partial}{\partial\rho}\left[\frac{p'J}{\rho^2 B^2}\frac{\partial}{\partial\rho}(\rho^2 g_{\theta\theta})\right] + \frac{\partial}{\partial\rho}\left(\frac{p'I}{\rho B^2}\frac{\partial g_{\rho\theta}}{\partial\zeta}\right) \right. \\ & \left. - \frac{1}{\rho}\frac{\partial}{\partial\theta}\left(\frac{p'I}{\rho B^2}\frac{\partial g_{\rho\rho}}{\partial\zeta}\right) - \frac{\partial}{\partial\rho}\left(\frac{p'I}{\varepsilon\rho B^2}\frac{1}{\rho}\frac{\partial g_{\rho\zeta}}{\partial\theta}\right) + \frac{\partial}{\partial\rho}\left[\frac{p'I}{\varepsilon\rho B^2}\frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho g_{\theta\zeta})\right]\right\}\frac{1}{\rho}\frac{\partial\Phi}{\partial\theta} \\ & + \frac{1}{2}\left\{\frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\frac{p'J}{B^2}\frac{\partial g_{\theta\theta}}{\partial\theta}\right) + \frac{1}{\rho}\frac{\partial}{\partial\theta}\left[\frac{p'J}{B^2}\frac{1}{\rho^2}\frac{\partial}{\partial\rho}(\rho^2 g_{\theta\theta})\right] \right. \\ & \left. - \frac{2}{\rho}\frac{\partial}{\partial\theta}\left(\frac{p'J}{B^2}\frac{1}{\rho}\frac{\partial g_{\rho\theta}}{\partial\theta}\right) + \frac{1}{\rho}\frac{\partial}{\partial\theta}\left(\frac{p'I}{\rho B^2}\frac{\partial g_{\rho\theta}}{\partial\zeta}\right) - \frac{1}{\rho}\frac{\partial}{\partial\rho}\left(\frac{p'I}{B^2}\frac{\partial g_{\theta\theta}}{\partial\zeta}\right) \right. \\ & \left. - \frac{1}{\rho}\frac{\partial}{\partial\theta}\left[\frac{p'I}{\varepsilon\rho B^2}\frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho g_{\theta\zeta})\right] + \frac{1}{\rho}\frac{\partial}{\partial\theta}\left(\frac{p'I}{\varepsilon\rho B^2}\frac{1}{\rho}\frac{\partial g_{\rho\zeta}}{\partial\theta}\right)\right\}\frac{\partial\Phi}{\partial\rho} \end{aligned} \quad (8)$$

Contribution to the evolution equation for the pressure:

$$\frac{\partial p}{\partial t} = \dots - \Gamma \frac{p_i}{en} \nabla p \cdot \nabla \times \frac{\mathbf{B}}{B^2} \quad (9)$$

$$\nabla \tilde{p} \cdot \nabla \times \frac{\mathbf{B}}{B^2} = \frac{\mu_0 \mathbf{J} \cdot \nabla \tilde{p}}{B^2} - \mathbf{B} \times \nabla \left( \frac{1}{B^2} \right) \cdot \nabla \tilde{p} = \frac{\mu_0 \mathbf{J} \cdot \nabla \tilde{p}}{B^2} + \frac{2}{B^3} \mathbf{B} \times \nabla B \cdot \nabla \tilde{p}$$

In dimensionless units,

$$\nabla \tilde{p} \cdot \nabla \times \frac{\mathbf{B}}{B^2} = \frac{p(0)}{B_0 a^2} \left\{ \frac{1}{B^2 \sqrt{g}} \left[ - \left( \frac{dJ}{d\rho} - \rho \frac{\partial \beta_*}{\partial \zeta} \right) \frac{1}{\rho} \frac{\partial \tilde{p}}{\partial \theta} + \left( \frac{1}{\rho} \frac{dI}{d\rho} - \frac{\partial \beta_*}{\partial \theta} \right) \frac{\partial \tilde{p}}{\partial \zeta} \right] + 2\Omega_d(\tilde{p}) \right\}$$

$$\begin{aligned} \nabla p_{eq} \cdot \nabla \times \frac{\tilde{\mathbf{B}}}{B^2} &= \frac{1}{\sqrt{g}} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( \frac{\tilde{B}_\zeta}{B^2} \right) - \frac{1}{R_0} \frac{\partial}{\partial \zeta} \left( \frac{\tilde{B}_\theta}{B^2} \right) \right] \frac{dp_{eq}}{d\rho} \\ &= \frac{1}{B^2 g} \frac{1}{R_0} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( -g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \Psi}{\partial \theta} + g_{\theta\zeta} \frac{\partial \Psi}{\partial \rho} \right) - \frac{1}{R_0} \frac{\partial}{\partial \zeta} \left( -g_{\rho\theta} \frac{1}{\rho} \frac{\partial \Psi}{\partial \theta} + g_{\theta\theta} \frac{\partial \Psi}{\partial \rho} \right) \right] \frac{dp_{eq}}{d\rho} \end{aligned}$$

In dimensionless units,

$$\begin{aligned} \nabla p_{eq} \cdot \nabla \times \frac{\tilde{\mathbf{B}}}{B^2} &= \frac{p(0)}{B_0 R_0 a} \frac{1}{B^2 g} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( -g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \Psi}{\partial \theta} + g_{\theta\zeta} \frac{\partial \Psi}{\partial \rho} \right) \right. \\ &\quad \left. - \varepsilon \frac{\partial}{\partial \zeta} \left( -g_{\rho\theta} \frac{1}{\rho} \frac{\partial \Psi}{\partial \theta} + g_{\theta\theta} \frac{\partial \Psi}{\partial \rho} \right) \right] \frac{dp_{eq}}{d\rho} \end{aligned}$$

Then

$$\frac{\partial p}{\partial t} = \dots - \frac{\Gamma \beta_{0i}}{2\varepsilon^2 \omega_{cy}} \frac{p_{ieq}}{n} \nabla p \cdot \nabla \times \frac{\mathbf{B}}{B^2} \quad (10)$$

where

$$\begin{aligned} \nabla p \cdot \nabla \times \frac{\mathbf{B}}{B^2} &= \frac{1}{B^2 \sqrt{g}} \left[ - \left( \frac{dJ}{d\rho} - \rho \frac{\partial \beta_*}{\partial \zeta} \right) \frac{1}{\rho} \frac{\partial \tilde{p}}{\partial \theta} + \left( \frac{1}{\rho} \frac{dI}{d\rho} - \frac{\partial \beta_*}{\partial \theta} \right) \frac{\partial \tilde{p}}{\partial \zeta} \right] + 2\Omega_d(\tilde{p}) \\ &\quad + \frac{\varepsilon}{B^2 g} \left[ \frac{1}{\rho} \frac{\partial}{\partial \theta} \left( -g_{\rho\zeta} \frac{1}{\rho} \frac{\partial \Psi}{\partial \theta} + g_{\theta\zeta} \frac{\partial \Psi}{\partial \rho} \right) - \varepsilon \frac{\partial}{\partial \zeta} \left( -g_{\rho\theta} \frac{1}{\rho} \frac{\partial \Psi}{\partial \theta} + g_{\theta\theta} \frac{\partial \Psi}{\partial \rho} \right) \right] \frac{dp_{eq}}{d\rho} \end{aligned} \quad (11)$$

There is a possible third contribution:

$$\tilde{p} \nabla p \cdot \nabla \times \frac{\mathbf{B}}{B^2} = 2\tilde{p} \Omega_d(p_{eq}) = \frac{\tilde{p}}{B^4 \sqrt{g}} \left( \frac{I}{\rho} \frac{\partial B^2}{\partial \zeta} - J \frac{1}{\rho} \frac{\partial B^2}{\partial \theta} \right) \frac{dp_{eq}}{d\rho}$$