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$$\dot{p}_\mu = \frac{\mathrm{d}}{\mathrm{d}\sigma}\left(-\frac{1}{L}g_{\mu\rho}\dot{x}^\rho\right) = g_{\mu\rho}\ddot{x}^\rho + \frac{1}{2}\left(\frac{\partial g_{\mu\rho}}{\partial x^\nu} + \frac{\partial g_{\mu\nu}}{\partial x^\rho}\right)\dot{x}^\nu\dot{x}^\rho.$$

$$\dot{p}_\rho = \frac{1}{2L}\frac{\partial g_{\mu\nu}}{\partial x^\rho}\dot{x}^\mu\dot{x}^\nu = \frac{1}{2L}\frac{\partial g_{00}}{\partial x^\rho}\dot{x}^0\dot{x}^0 = -\frac{2GMx_\rho}{2Lc^2r^{3/2}}\left(\dot{x}^0\right)^2.$$