So far, the sign of Γ has not been determined. Examination of V shows that its radial derivative is always negative unless Γ is positive:

$$\mathbf{r} \cdot \nabla V = -\frac{q^2 \mathfrak{M}^2}{\gamma m} \left[\frac{\Gamma}{\rho} - \frac{\rho}{r^3} \right] \left[\frac{\Gamma}{\rho} - \frac{2\rho}{r^3} \right] \tag{2.12}$$

A negative radial derivative for the potential corresponds to a repulsive radial force. Consequently, all orbits characterized by a negative Γ must extend to infinity and cannot be trapped. When Γ is positive, V has a minimum on the line

$$r = \Gamma^{-1} \cos^2 \lambda \tag{2.13}$$

Particles of sufficiently low energy will be confined to the vicinity of this line, and we have

$$r_0 = \Gamma^{-1} \tag{2.14}$$

To examine what is meant by 'sufficiently low energy,' it is useful to simplify the problem further by the introduction of dimensionless variables

$$z' = \Gamma z \tag{2.15a}$$

$$\rho' = \Gamma \rho \tag{2.15b}$$

$$\phi' = \phi \tag{2.15c}$$

$$t' = \Gamma^3 q \mathfrak{M} (\gamma m)^{-1} t \tag{2.15d}$$

Equations 2.6, 2.7, 2.10, and 2.11 now take the simpler form

$$\mathfrak{H} = \tfrac{1}{2}(p_z^2 + p_\rho^2) + V \tag{2.16}$$

$$V = \tfrac{1}{2}[(1/\rho) - (\rho/r^3)]^2 \tag{2.17}$$

$$\mathfrak{H} = \text{constant} = 1/32\gamma_1^4 \tag{2.18}$$

$$\phi = \int dt\, [(1/\rho^2) - (1/r^3)] \tag{2.19}$$