

Stellar Structure Equations

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The following equations are referenced from former Duke undergraduate Emily Kuhn's senior thesis. These equations of state for pressure and density result from the $N = 1$ solution to the Lane-Emden Equation, and the functions for gravitational potential are solutions to the Poisson Equation for a central mass characterized by the chosen EOS.

$$\rho(r) = \rho_c \frac{\sin(\pi r/R)R}{r\pi} \quad r < R \quad (1)$$

$$P(r) = K\rho(r)^2 \quad (2)$$

$$\varphi_{core} = 4G\rho_c \left(-\frac{R^2}{\pi} - \frac{M}{4R\rho_c} \right) \quad (3)$$

$$\varphi_{inside}(r) = 4G\rho_c \left(\frac{-R^3 \sin(\pi r/R)}{\pi^2 r} - \frac{M}{4R\rho_c} \right) \quad (4)$$

$$\varphi_{outside}(r) = -\frac{GM}{r} \quad (5)$$