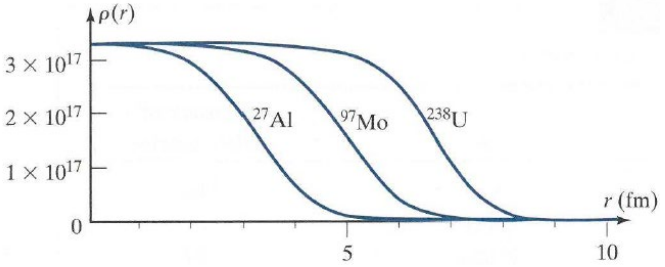
HOMEWORK SET 24: NUCLEAR PROPERTIES
Due Friday, April 18, 2025

PROBLEMS FROM OR AFTER TZDII[1]

TZDII 16.7) Find the mass of the ^{12}C atom in Appendix D. What fraction of its mass is contained in its atomic electrons?

TZDII 16.10) Use the formula (16.3), $R = R_0A^{1/3}$, with $R_0 = 1.07$ fm, to find the approximate radii of the most abundant isotopes of carbon, iron, and lead. (Mass numbers and abundances are in Appendix D.)

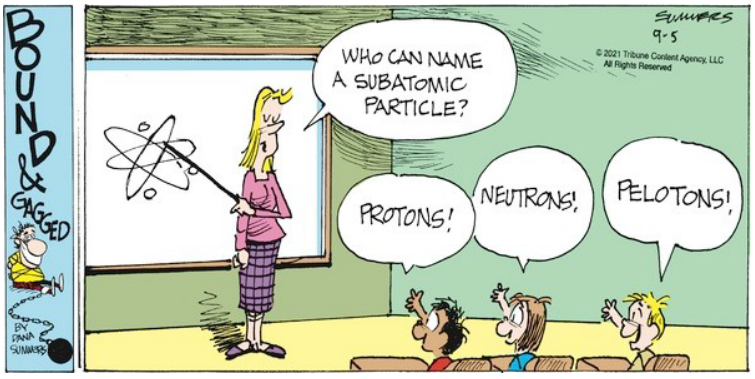
FIGURE 16.2
The density, in kg/m^3, as a function of r in the nuclei of aluminum, molybdenum, and uranium. These graphs can be accurately fitted by an analytic expression called the Fermi function. (See Problems 16.15 and 16.63 to 16.65.)

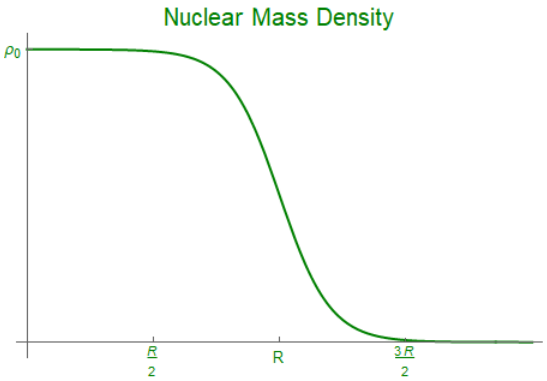


TZDII 16.15) The density of mass inside a nucleus is shown in Fig. 16.2. There is no simple theory that predicts the exact shape shown, but it is found that the shape can be approximated by the following mathematical form, known as the Fermi function:

$$\rho(r) = \frac{\rho_0}{1 + e^{(r-R)/t}}$$

where ρ_0, R, and t are positive constants, with $t << R$. **a)** Prove that $\rho = \rho_0/2$ at $r = R$. **b)** Show that the maximum value of ρ occurs at $r = 0$ and is very close to ρ_0, given that $t << R$. (HINT: TO FIND THE MAXIMUM, FIND WHEN THE DENOMINATOR IS A MINIMUM) **c)** Sketch of ρ as a function of r is done for you below. **d)** Prove that as r increases, the density falls from 90% to 10% of ρ_0 in a distance $|\Delta r| = 4.4t$. (Thus t characterizes the thickness of the surface region.) (HINT: EVALUATE $\rho/\rho_0 = 10/9$ AND $10/1$, SOLVE FOR $r_{0.9}$ AND $r_{0.1}$ THEN FIND $|r_{0.9} - r_{0.1}|$).





[1] Taylor, Zafiratos, & Dubson, *Modern Physics for Scientists and Engineers*, 2nd Editon, Pearson, Prentice Hall, 2004