

HOMEWORK SET 22: NUCLEAR PROPERTIES

Due Monday, April 15, 2024

PROBLEMS FROM OR AFTER TZDII¹

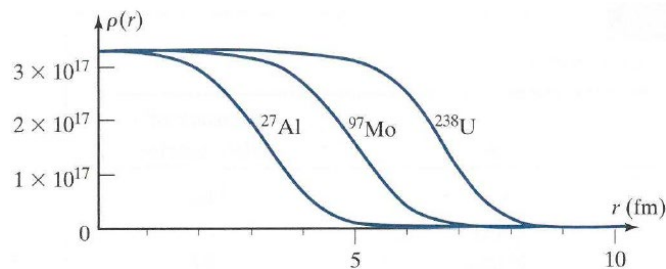
WHEN YOU GET A RESULT, COMMENT ON IT!! DOES IT MAKE SENSE, IS IT INTERESTING, IS IT RIDICULOUS AND INDICATE THAT THE MODEL DOESN'T WORK VERY WELL?

TZDII 16.7) Find the mass of the ^{12}C atom in Appendix D². What fraction of its mass is contained in its atomic electrons?

TZDII 16.10) Use the formula (16.3), $R = R_0 A^{1/3}$, 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

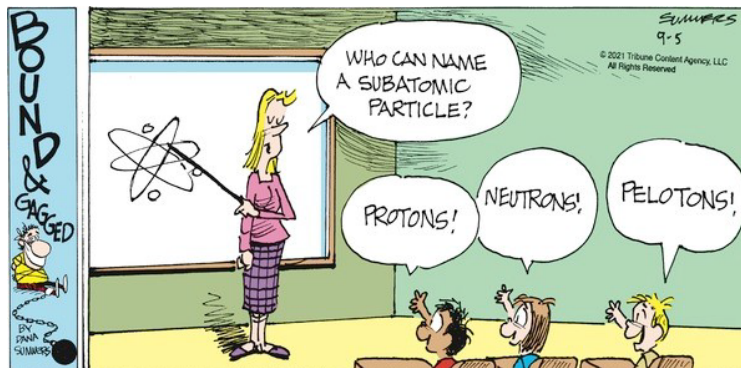
The density, in kg/m^3 , as a function of r in the nuclei of aluminum, molybdenum, and uranium. These graphs can be accurately fitted by an analytic expression called the Fermi function. (See Problems 16.15 and 16.63 to 16.65.)



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 $t \ll R$. **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 $t \ll R$. **c)** Sketch ρ as a function of r (USE A COMPUTER). **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.)



<https://xkcd.com/2100/>

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

² Appendix D from TZDII is available as a pdf on the T drive.