13. Optical model potential depths

Figure 13 shows a comparison of measured optical model potential depths from [28] with the Thomas-Fermi calculations. At this stage all the parameters except σ were frozen at the values deduced from fitting ground state masses and the surface diffuseness, so what you see is a one-parameter fit to the depths. This is another example where our model provides a closed formula for the property in question. According to our model the potential depth $U(\tau)$ felt by a nucleon with kinetic energy τT_0 traveling through standard nuclear matter is given by

$$U(\tau)/T_0 = -\alpha + \frac{3}{5}\beta + \frac{4}{3}\sigma + \beta\tau - \gamma \begin{cases} \tau^{-1/2} & \text{for} \quad \tau > 1 \\ \frac{3}{2} - \frac{1}{2}\tau & \text{for} \quad \tau < 1 \end{cases} . \tag{21}$$

The total energy of the nucleon is $E = U + \tau T_0$, so Eq. 21 provides an explicit relation between U and E, which is plotted in Fig. 13. Again, the agreement with measurements is close, though not perfect.

At this stage we decided to freeze our parameter set at the values listed in Section 4 and to explore the predictions of our model under various extreme conditions. Here are three examples.

14. Nuclei at the drip lines

Figure 14 shows the neutron and proton chemical potentials for isotopes of Sn from neutron number N = 120 down to N = 32. The former is the last isotope which, in the Thomas-Fermi model without shell and pairing corrections, would be stable against neutron emission. The latter, for which the proton chemical potential is plus 8.24 MeV, would be unstable against proton radioactivity by quantal barrier penetration, but would be classically metastable. Figure 15 shows the neutron and proton density distributions for ^{82}Sn, ^{120}Sn and ^{170}Sn.

15. How unbound is neutron matter?

The energy per particle of neutron matter is given by Eq. 15, which leads to