Name: PHY625 (Fall 2014), 09/01/14

Homework Assignment #1

(*Due Date*: Monday, Sept. 08, 01:50pm, in class)

1.1 *Empirical Features of the N-N Force* *(3+1 pts.)*

(a) Quote and briefly explain empirical evidence for 3 important features of the nucleon-nucleon interaction.

(b) How can the features mentioned in part (a) lead to basic propeties of nuclear binding, i.e., the presence of bound nuclei and the approximate constancy of the interior nuclear density.

1.2 *Meson Exchange Model for Nuclear Forces* *(6 pts.)*

In this problem we develop a schematic model for nuclear forces and saturation based on meson-exchange interactions.

(a) Show that the Fourier transform of a static scalar meson-exchange potential,

$$V_\alpha(q) = -g_\alpha^2 \, \frac{1}{\vec{q}^2 + m_\alpha^2} \ , \tag{1}$$

yields the standard Yukawa potential in coordinate space, $V(r) = -g_\alpha^2/(4\pi)\,\mathrm{e}^{-m_\alpha r}/r$.

(b) Graph the r-dependence (in units of [fm]) of the attractive scalar potential (in [MeV]) from σ exchange (α=σ, $m_\sigma = 510\,\mathrm{MeV}$, $g_\sigma = 12$) and of the repulsive scalar potential from ω exchange (α=ω, $m_\omega = 782\,\mathrm{MeV}$, $g_\omega = 25$), as well as their sum (use the conversion factor $\hbar c = 197.33\,\mathrm{MeV\,fm}$).

(c) Determine the minimum of the total potential from your result in part (b) and use it to estimate the ground-state (or saturation) density of infinite nuclear matter, as well as the binding energy per nucleon. Assume 6 nearest neighbors and an average kinetic energy of $E_{\rm kin} \simeq 35\,\mathrm{MeV}$ per nucleon.