correction). The nuclear energy is a sum of neutron-neutron, proton-proton (i.e., "like") and neutron-proton (i.e., "unlike") interaction energies:

$$W_{nn\ \mathrm{or}\ pp} = \frac{1}{2}\int d^3r_1 \int d^3r_2 \int_{n\ \mathrm{or}\ p} d^3p_1 \int_{n\ \mathrm{or}\ p} d^3p_2 \left(2/h^3\right)^2 \quad v_{12}(\mathrm{like}) \tag{1}$$

$$W_{np} = \int d^3r_1 \int d^3r_2 \int_{n} d^3p_1 \int_{p} d^3p_2 \left(2/h^3\right)^2 \quad v_{12}(\mathrm{unlike})\,. \tag{2}$$

Here $2/h^3$ is the neutron or proton density in the phase spaces $\bar{r}_1, \bar{p}_1$ and $\bar{r}_2, \bar{p}_2$ for particles 1 and 2, the integrals are over those phase spaces, and v_{12}(like), v_{12}(unlike) are the effective interaction potentials between the two like or unlike particles. A clever choice of these effective interactions is a challenge to nuclear Thomas-Fermi practitioners, where art and science come together.

3. The effective interaction

We have generalized the Seyler-Blanchard interaction by adding one momentum-dependent and one density-dependent [22] term:

$$v_{12} = \underbrace{2T_0\rho_0^{-1}\cdot Y(r_{12})\cdot\left[-\alpha+\beta(p_{12}/P_0)^2\right.}_{\text{Seyler–Blanchard}}\left.-\gamma(p_{12}/P_0)^{-1}+\sigma(2\bar{\rho}/\rho_0)^{2/3}\right] \tag{3}$$

Extra attraction increases when p_{12} is small (and particles would like to become correlated), and tends to zero for large p_{12}, when particles would zip past each other.

Repulsion increases with increasing average density $\bar{\rho}$.

In the above, the quantities T_0, P_0, ρ_0 are the Fermi energy, the Fermi momentum and the particle density of standard nuclear matter. (They serve as convenient units.) $Y(r_{12})$ is a normalized Yukawa interaction of range a: