your name(s)______________________________

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Physics 851 Quiz #2 - Fridays, Sept. 20th and 27th

Consider two nucleons, mass = 939 MeV/c^2. They bind into a deuteron with a binding energy of 2.2 MeV. Consider a potential,

$$V(r) = \begin{cases} \infty, & r < 0 \\ -V_0/[1 + e^{(r-a)/a}], & r > 0 \end{cases},$$

where $a = 0.707$ fm. Perform the following calculations numerically.

1. Find V_0, numerically, so that the binding energy is indeed 2.2 MeV.
2. Using your value of V_0, find and plot the phase shift (in degrees) as a function of relative momentum, $q = |\vec{p}_1 - \vec{p}_2|/2$, for $q < 100$ MeV/c in 2 MeV bins.

FYI: $\hbar c = 197.327$ MeV·fm. You can treat this as a one-dimensional problem, where $r < 0$ is suppressed by an infinite repulsive potential. Also, don't forget to use the reduced mass μ. Schrödinger's equation for an s-wave is the same as for a one-dimensional problem,

$$-\frac{\hbar^2}{2\mu}\partial_r^2\phi_0(r) + V(r)\phi_0(r) = E\phi_0(r).$$

The phase shift for scattered waves is such that the solution for $r >> a$ is

$$\psi_k(r) \sim e^{-ikr} - e^{ikr+2i\delta(k)}.$$

The phase shift at $q = 0$ should be 180 degrees (because of the bound state). When calculating delta, add or subtract integral numbers of 180 degrees to make the phase shift a continuous function.