Fall Term 2006

22.02 Introduction to APPLIED NUCLEAR PHYSICS

Problem Set #6

Prof. Molvig

Passed Out: October 31, 2006 DUE: November 8

, 2006

1. Prove that the kinetic energy of a two particle system can be expressed in Center-of-Mass coordinates,

$$\begin{aligned}\mathbf{R} &= \frac{1}{m_1+m_2}\left(m_1\mathbf{x}_1+m_2\mathbf{x}_2\right)\\ \mathbf{r} &= \mathbf{x}_1-\mathbf{x}_2\end{aligned}$$

as,

$$E_{kin}=\frac{(m_1+m_2)}{2}\dot{\mathbf{R}}^2+\frac{\mu}{2}\dot{\mathbf{r}}^2$$

where,

$$\mu=\frac{m_1m_2}{m_1+m_2}$$

is the reduced mass. Suggest proof by demonstration, substituting the formulas for *big* R and *little* r and recovering original kinetic energy in terms of x_1 and x_2.

2. Krane, problem 4.2

3. Krane, problem 4.4 (*hint:* use the known, $E = 2.2\ MeV$, to evaluate the wavenumbers, $k_1,\ k_2$ = imaginary part of wavenumber in Krane notation (we would have called this, κ))

4. Show (using ESTIMATES) that the deuteron has no excited states. *Estimate* the excited state energy from both higher order radial eigenfunctions or from non-zero angular momentum.

5. Prove that the di-neutron cannot exist. Use the antisymmetric property of the wavefunction for Fermions to show that the di-neutron spin state must be the singlet (triplet dissallowed for Fermions) state and that we know from the spin dependence of the nuclear force that the singlet state cannot be bound. Use the result that the, $l = 0$, angular momentum state is symmetric under particle exchange so that it is left to the spin state to be antisymmetric as required of Fermions.