Exercises in Advanced Quantum Mechanics

Due Thursday, January 22, 2015

32. We consider a system of two identical particles of mass m and spin $\frac{1}{2}$ moving in a harmonic oscillator potential and interacting by a force proportional to their distance:

$$H = -\frac{\hbar^2}{2m}\left(\Delta_1 + \Delta_2\right) + \frac{m\omega^2}{2}\left(\vec{x}_1{}^2 + \vec{x}_2{}^2\right) + \frac{m\sigma^2}{2}(\vec{x}_1 - \vec{x}_2)^2 \, .$$

a) Solve the Hartree-Fock equations for this system.

b) Determine the exact eigenvalues and eigenvectors and compare your result with that of part a).   *Hint.* Transform the system to normal coordinates

33. (Mandatory) We consider a one-dimensional harmonic oscillator of mass m and frequency ω in the ground state. At time $t = 0$, a constant external force F is turned on. Determine the exact transition probabilities to each of the new excited states for $t > 0$.