Physics 402
Spring 2019
Prof. Belloni
Discussion Worksheet for March 6, 2018

1. Write down the Hamiltonian for two non-interacting identical particles in the infinite square well of width a. Verify that the Fermion ground state given below is an eigenfunction of the Hamiltonian and find the eigenvalue.

$$\Psi(x_1, x_2) = \frac{\sqrt{2}}{a}\left[\sin\left(\frac{\pi x_1}{a}\right)\sin\left(\frac{2\pi x_2}{a}\right) - \sin\left(\frac{2\pi x_1}{a}\right)\sin\left(\frac{\pi x_2}{a}\right)\right]$$

(note: the Hamiltonian is $H = -\frac{\hbar^2}{2m}\nabla_1^2 - \frac{\hbar^2}{2m}\nabla_2^2$ inside the well, where $V = 0$)

2. Find the next excited state eigenfunction and eigenvalue for two identical Fermions in the infinite square well.

3. The Slater determinant is a very handy way to construct antisymmetric wavefunctions of N-identical particle systems. Suppose you want to distribute particles into states *a*, *b*, *c*, etc. One forms rows of a determinant made up of $\psi_a(1)$ $\psi_b(1)$ $\psi_c(1)$ … followed by the next row, written as $\psi_a(2)$ $\psi_b(2)$ $\psi_c(2)$ … , where "1" and "2" represent the coordinates of particle 1, particle 2, etc. Multiply the determinant by $1/\sqrt{N!}$ for normalization.

a) Form the antisymmetric wavefunction for two identical particles in states *a* and *b*.

b) Form the antisymmetric wavefunction for three identical particles in states *a, b* and *c*. See what happens if *a* and *c* are the same state.