Physics 4410
Quantum Mechanics 2

Lecture 8

Bosons and fermions

September 11, 2020

1. Describe the Hilbert space of a two particle system.

2. Describe the particle exchange operator P.

3. What is a bosonic state? What is a fermionic state?

4. Describe the wave functions of a pair of spin-$\frac{1}{2}$ fermions.

5. When does a Hamiltonian describe quantum indistinguishable particles?

Activity: Consider a 3 level system with single particle Hamiltonian

$$H^{\rm sp} = \gamma \left[|a\rangle\langle a| + 2|b\rangle\langle b| + 3|c\rangle\langle c| \right], \quad (\gamma > 0).$$

We have two indistinguishable particles, and $H = H_1^{\rm sp} + H_2^{\rm sp}$.

(a) How many states are allowed if the particles are bosons? What is the ground state?

(b) How many states are allowed if the particles are fermions? What is the ground state?

(c) What is the ground state energy if the particles are spin-$\frac{1}{2}$ fermions?