José A. Morales E., UTSA Math and Physics & A. Depts.

Abstract

Problems to review concepts on IDENTICAL PARTICLES: (a) symmetry of the many-particle wave function of identical fermions; (b) symmetry of the many-particle wave function of identical bosons; (c) spin & atoms; (d) solids and origin of their band structure.

1. Consider the following situation:
   (a) Two identical noninteracting particles of mass m are placed in a box of width L. Draw an energy level diagram showing the first half-dozen or so states of the system. Indicate the degeneracy due to exchange, if any, of each energy level.
   (b) Suppose the particles have a weak, attractive interaction. Show qualitatively what happens to the states of the system.
2. McIntyre 13.9: Calculate the one-particle probability density $P(x_1)$ by integrating the two-particle probability density $P(x_1, x_2)$ over the position x_2 of particle 2 (i.e., projecting the two-particle probability density onto the x_1 axis). Do this for the three cases of
   (a) distinguishable particles (of the same mass),
   (b) identical particles in a symmetric spatial state, and
   (c) identical particles in an anti-symmetric spatial state.
   (d) Bonus: demonstrate that measuring the position of one particle independent of the location of the other particle is the same for all three cases.
3. McIntyre 13.13: Consider the first excited state of helium where one electron is in the $n = 1$ hydrogenic state and the other electron is in the $n = 2$ hydrogenic state.
   (a) Using term or spectroscopic notation, list all the allowed states of this system.
   (b) How many total states are there?
   (c) What is the energy of this level, ignoring the interactions of the electrons with each other?
   (d) Describe qualitatively the shifts of this energy level that result from considering the interactions of the electrons with each other.