November 16, 2010

PHY 741 – Problem Set #25

Continue reading Chapter 9 in **Mahan**; homework is due Friday, November 19, 2010.

Consider two identical particles, which have a spherically symmetric and spin-independent interaction, and which scatter in the center of mass frame of reference. In class, we showed that the differential scattering cross section in the center of mass frame takes the form:

$$\frac{d\sigma_c}{d\Omega} = |f_c(k,\theta) \pm f_c(k,\pi-\theta)|^2,$$

where k denotes the magnitude of the wave vector in the center of mass frame and $f_c(k,\theta)$ denotes the scattering amplitude which is expressed in terms of phase shifts $\delta_l(k)$.

$$f_c(k,\theta) = \frac{1}{k}\sum_{l=0}^{\infty}(2l+1)\mathrm{e}^{i\delta_l(k)}\sin\delta_l(k)P_l(\cos\theta).$$

The $\pm$ sign depends upon whether the particles obey Fermi or Bose statistics and on the spin configuration of each case c. Assume that the incident and target particles have uniform populations of all possible spin states and consider the form of the complete differential cross section

$$\frac{d\sigma}{d\Omega} = \sum_c P_c \frac{d\sigma_c}{d\Omega},$$

where P_c denotes the probability of the particular case c.

Find the form of the cross section for each of these cases:

1. The particles obey Bose statistics and each has spin 0.
2. The particles obey Bose statistics and each has spin 1.
3. The particles obey Fermi statistics and each has spin 1/2.
4. The particles obey Fermi statistics and each has spin 3/2.