**Tareas 10 Tópicos de la Física Moderna**

24 de Noviembre 2020

1. Protons in a plasma fusion reactor have a temperature of $3 \cdot 10^7\,\mathrm{K}$. (a) What is the average kinetic energy of the protons? (b) The density of protons in the plasma is $10^{21}\,\mathrm{m}^{-3}$. Can we describe the system with Maxwell-Boltzmann statistics?

2. Write down the total wavefunction for a system of four identical bosons.

3. Write down the total wavefunction for a system of four identical fermions.

4. For what energy is the Bose-Einstein factor equal to 10 at room temperature?

5. Consider a system of 6 spin-1/2 fermions sharing 10 units of energy. Determine the energy distribution function $df/dE$. Make an estimate of the Fermi energy.

6. Make an analogy between the helium-scattering experiment and the double-slit experiment.

7. Consider the scattering of two $^3He$ nuclei or two $^4He$ nuclei at small angles. Is there quantum interference? Explain!

8. For a gas of particles at fixed temperature, which particle type, fermion or boson, causes the greatest pressure? Why?

9. Which system has more states available at 1 eV, a gas of electrons or a gas of photons? Why?

10. (a) Why are there no states of zero energy for a distribution of thermal photons?
    (b) Why are there no states of zero energy for a distribution of electrons in a metal?

11. For the first time a gas of atoms obeying the Fermi statistics was observed in September 1999. Read and comment the article in Science **285** (1999) 1703. Also discuss the difference to a Bose-Einstein Condensate (BEC).