Due: Thursday, 02/16

4. What are pure and mixed light-polarization states? Show that a necessary and sufficient condition for light to be of pure polarization is that its normalized density matrix has the property: $\rho^2=\rho$.

5. Consider a model of collisional spectral-line broadening in which it is assumed that a radiating atom (with unperturbed radiation frequency ω_0) undergoes collisions which have the property that the radiation phase after the collision is random (i.e., the atom "does not remember" which phase it was radiating at prior to the collision). The amplitude of radiation can be assumed constant. Assuming that the mean time between successive collisions is τ, and that collisions are the dominant source of line broadening, determine the spectral line shape $I(\omega)$ of the radiation. Express the full width at half maximum (FWHM) of the spectral line in terms of τ.

6. An exercise in practical units.

a) What is the value of the Bohr magneton μ_0 in SI units, in Gaussian units, and in Hz/G ?

b) Consider a paramagnetic atom with the ground-state magnetic moment of 1 μ_0. What is the energy of such atom immersed in a magnetic field of 1 T if it is prepared in a state with minimal possible projection of the magnetic moment on the direction of the magnetic field? Express this energy in J, erg, eV, cm^{-1}, and K. Discuss implications for magnetic trapping of atoms.

c) Electric dipole moments are often measured in units of debye (1 D = 10^{-18} esu). Express the quantity ea_0 (where e is the magnitude of the electron's charge and a_0 is the Bohr radius) in debye and in Hz/(V/cm). What is the energy of a molecule with a dipole moment of 1 D in an electric field of 100 kV/cm? (The last question may be unsettling to those who know that molecules cannot possess a permanent electric dipole moment, EDM, unless there is P and T violation – we will be sure to talk about this in class).

The values of the fields (1 T and 100 kV/cm) are representative of what can be available in a laboratory.