**ASTR 601 Problem Set 3: Due Thursday, October 23**

1. (4 pts) Dr. Sane has observed a light source which he is sure indicates the presence of aliens. His evidence for this is that a light source slightly displaced from a star has 5% polarization. Dr. Sane's idea is that aliens have set up a perfectly reflecting sphere, and unpolarized point source of light scatters off the mirror and to us. The National Enquirer has contacted you for a comment.

(a) (3 pts) Granting Dr. Sane's assumptions, derive the angle between the vector between the light source and the mirror, and the vector between the mirror and us.

(b) (1 pt) Name at least two ways other than aliens that we could have a polarization fraction of 5% in light.

2. (4 pts) Suppose that a hydrogen atom really could be described using a "solar system model" in which a classical electron (treated as a point mass with mass $m_e = 9.11 \times 10^{-28}$ g) orbits in a circle around a classical proton (treated as an infinitely massive point mass). The electron moves in a circle so that its initial kinetic energy is $E_K = 13.6$ eV and its initial electrostatic potential energy is $E_V = -27.2$ eV, but as the electron radiates energy its separation from the proton decreases. At all points, however, $E_K = -(1/2)E_V$. We will use nonrelativistic kinematics, so that $E_K = (1/2)m_e v^2$ at speed $v$, and $E_V = -e^2/r$ at separation $r$. Given these assumptions, and the assumption that the electron emits power according to the Larmor formula, calculate to within a factor of 2, in seconds, how long it would take for the electron to reach zero distance from the proton. It will be helpful for you to know that the Bohr radius (which is the $r$ at which we get $E_V = 27.2$ eV) is given by $r_0 = \hbar^2/(m_e e^2)$, where $\hbar = h/(2\pi)$ and $h$ is Planck's constant.

3. (4 pts) In one frame, we see a single stationary electron, which thus has an electric field but zero magnetic field. Explicitly find a Lorentz transformation to a frame in which the EM field is purely magnetic (no electric field), or prove that it is impossible.

4. (4 pts) Write a code to do a random walk using Thomson scattering, starting at the center of a uniform sphere of radius $R = 10\ell$, where $\ell$ is the mean free path. Determine the mean distance traveled to reach radius $R$, compare with what we would have with isotropic scattering, and explain the difference. **As before, please send me a copy of your code before you hand in your homework on the due date, which should include a statement about the mean distance in units of $\ell$. Any language is fine as long as it compiles and runs on my departmental machine (please send me compilation/run instructions); I won't install any libraries or download modules!**