**ASTR 601 Problem Set 1: Due Thursday, September 14**

1. A sphere oscillates radially (i.e., it expands and contracts) in a fluid of density $\rho$ and sound speed $c_s$. Which of the following could be true about the intensity $I$ (energy per time) of the sound waves produced by the oscillation? Here $V$ is the instantaneous volume of the sphere.

A) $I = \rho(dV/dt)c_s^2/4\pi$
B) $I = \rho(d^2V/dt^2)^2/(4\pi c_s)$
C) $I = \rho c_s^8/(4\pi d^5V/dt^5)$
D) $I = \rho(d^2V/dt^2)c_s/4\pi$

In order to get full credit for this problem you need to assess *each* of the possible solutions. That is, you need to determine whether each of the solutions *could* be correct. If you find something definitely wrong with a solution you can move on to the next possibility, but just passing a single test is not enough.

2. For this problem we will use the first part of the practice problem for specific intensity.

Suppose that there are two intrinsically identical and isotropically-emitting galaxies, one at redshift $z_1$ and the other at redshift $z_2$. Both are at rest relative to the local Hubble flow. We assume that both redshifts are large enough that they effectively have the same proper distance from us.

a. What do we measure to be the ratio of their surface brightnesses?

b. What do we measure to be the ratio of their bolometric fluxes?

In all cases we assume that there is no absorption, scattering, or gravitational lensing between the galaxies and us; the photons simply travel in a vacuum.

3. Say that we are at the origin of a coordinate system, and that we have a set of identical, unmoving, flat circular disks, each of which has infinitesimal thickness and radius $R$. The centers of the disks are distributed randomly in space, with an average number density of $n$, and all of them are oriented so that the normal to the disk points toward the origin. *Derive* the average distance that you would need to travel in a straight line before you hit a disk. As with any derivation you do in this class, you should check units, limits, and symmetries as appropriate.

4. Dr. I. M. N. Sane, iconoclastic renegade of astrophysics, has discovered strange stars! He analyzed the flux and spectrum of what establishment scientists might call a neutron star. Knowing the distance to the star, he was able to determine the luminosity $L$. The spectrum is perfectly fit by a blackbody of temperature $T$, so all Dr. Sane needed to do to get the radius $R$ was to use the blackbody formula for luminosity: $L = 4\pi\sigma_{\rm SB}R^2T^4$, where $\sigma_{\rm SB} = 5.67 \times 10^{-5}$ erg s$^{-1}$ cm$^{-2}$ K$^{-4}$ is the Stefan-Boltzmann constant. Using this approach, Dr. Sane has found that the radius of the star is 5.37 km, which is so small that it can only be a strange star (neutron stars have radii $\sim 12 - 13$ km).

The astronomy editor for Nature, Dr. Leslie Sage, has received Dr. Sane's manuscript and has asked you to review it for accuracy. As part of your assessment, you should take into account the following. When photons pass through a compact star atmosphere one can indeed assume that deep down the photons are arranged in a blackbody. However, as they get toward the surface, most of the photons scatter a few times and then are absorbed back into the atmosphere. In the case analyzed by Dr. Sane, only 20% of the photons escape; thus you can assume that although the *spectrum* of the photons is identical to a blackbody, for a given temperature $T$ the *flux* of photons is only 20% that of a blackbody.

Use this information to report on Dr. Sane's discovery. In particular, what is your estimate of the radius given this information?