

**Astronomy 501 Spring 2013**  
**Problem Set #4**

Due in class: Friday, Feb. 15

Total points: 7+0.5

1. **[1.5 points]** Rybicki & Lightman, Problem 3.1. Each part is worth 0.5 points.
2. **[2.5 points]** Rybicki & Lightman, Problem 3.2. Each part is worth 0.5 points.
3. **[1.5 points]** Rybicki & Lightman, Problem 3.4. Each part is worth 0.5 points.
4. *Emission from Spinning Dust*
  - (a) **[0.5 points]** Estimate the power emitted by a single spherical charged dust grain of radius  $a$  spinning at  $\nu$  GHz. Assume the charge is fixed on a site on the surface of the dust grain.
  - (b) **[0.5 points]** Equate the rotational energy of the dust to  $kT$ , and model the grain as a spinning sphere of  $a$  and density  $\rho$  to find the characteristic frequency of emission  $\nu$ .
  - (c) **[0.5 points]** Assume  $\rho = 3\text{g cm}^{-3}$  and  $T = 6000\text{K}$ . What radius grains will give rise to emission at 20 GHz? How many atoms would such a grain contain?  
See Draine & Lazarian (1998) for more details, and arXiv:1101.2031 for some recent relevant observational data.
5. **[0.5 bonus points]** On question 3(b) of Problem Set 2, I believe my solution may have a mistake. I am unaware of an error, but a reputable source does not get my numerical factor of  $3^{-1/4}$ , but rather  $[2/(3\pi)]^{1/4}$ . Unfortunately the reputable source does not give a detailed derivation.  
So for 0.5 bonus points, find out who is right, and explain what confusion leads to the wrong result.