(AST 461) Problem Set 1

1. The solar luminosity is 3.8×10^{33}erg/sec and the solar radius is 7×10^{10}cm, and the Earth-Sun distance is 1.5×10^{13}cm.

a) What is the total flux at the earth?

b) what is the frequency integrated (specific) intensity? Calculate this at the Sun and at the Earth. What is their ratio?

2. It has been proposed that neutron stars (compact, gravitationally collapsed end states of stars which are extremely dense ($10^{17} kg/m^3$), and all matter is compressed into neutrons) which are accreting surrounding material from their strong gravity are surrounded by a 10^8cm plasma corona of ionized gas, with Thompson scattering depth $\tau \sim 10$. Suppose that the neutron star rotates with period 1.6 milliseconds. Could we detect the rotational modulation of the emission from the neutron star?

3. A gamma-ray burst (GRB) is observed once per day, somewhere on the sky. The total luminosity is about 10^{53}erg/s and they last for typically a few seconds. From variability and relativity, we know that the size of the GRB emitting region is about 10^{15}cm. Post GRB emission is now also observed in the X-ray and optical bands. And is thought to result from the deceleration of a relativistic expanding and radiating wind. As the Hubble space telescope (HST) can resolve a source 0.1 arc seconds in diameter, if a GRB went off in Andromeda (700 kiloparsecs=2×10^{24}cm away), would HST measure its optical intensity or its flux? If the optical afterglow begins just after the GRB emission, at what radius would the object have to be for this answer to change? What is the value of the measured quantity at that distance? Compare the value to that of the Sun.

4. Derive Einstein relations when the two-state atomic system is in equilibrium with a neutrino field rather than a photon field. (Assume neutrinos to be massless fermions).

5. Consider a 1-D slab of front back symmetric scatterers of total optical depth $\tau >> 1$ illuminated normally, from above. Show that the flux and angle averaged intensity $J = \bar{I}$ below the layer are $a/(\tau + b)$ times those above where a and b are constants order 1. Use the two-stream approximation.

6. Rybicki and Lightman Problem 1.4

7. Rybicki and Lightman Problem 1.5

8. Rybicki and Lightman Problem 1.10