Homework Assignment #10 is due MONDAY, Dec. 21, 2015
(please note the different date)

Theoretical Astrophysics (MKTP2)

Winter Semester 2015/2016
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1. **Thermal radiation** *25 points*

A spherical gas cloud of radius R and temperature T emits thermal radiation at a rate $P(\nu)$ (power per unit volume and frequency range). Its distance from the Earth is d with $d \gg R$.

(a) First assume the cloud is optically *thin*. What is the brightness of the cloud measured on Earth? Assume the cloud is viewed along a parallel ray which has a distance b from the cloud center.

(b) What is the effective temperature of the cloud?

(c) What is the flux F_ν measured at the Earth coming from the entire cloud?

(d) How does the measured brightness temperature compare with the cloud's temperature? The brightness temperature T_b is defined by the equation

$$I_\nu = B_\nu(T_b) \tag{1}$$

where B_ν is the black body spectrum.

(e) What are the above answers for an optically *thick* cloud?

2. **Eddington limit** *10 points + 5 bonus points*

(a) Derive the conditions under which a star with luminosity L_* and total mass M can disperse optically thin gas in its surrounding. The result is $M/L < \kappa/(4\pi\, G\, c)$, where κ is the frequency independent mass absorption coefficient. Consider the problem in spherical symmetry.

(b) Calculate the terminal velocity of the gas in this case. Assume the gas is accelerated away from the center in the gravitational potential of the star.

(c) Calculate the Eddington luminosity of the star, i.e. the critical luminosity at which a central source starts to disperse its environment. Use the minimum value of κ which you can estimated from Thomson scattering off free electrons in a fully ionized hydrogen plasma. Express your result as a function of the stellar mass in units of $M_\odot$. *5 bonus points*