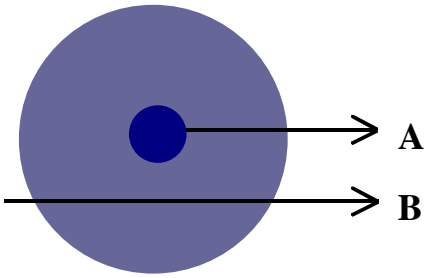
ASTR 3730: Astrophysics 1 – Problem Set #3

Due in class Thursday October 6th

1) An optically thick source of blackbody radiation at temperature T_{source} is surrounded by an optically thin cloud of gas at temperature T_{cloud}:



If an atomic transition in the optically thin gas corresponds to a frequency ν_0, sketch the spectrum you would expect to see in the vicinity of this spectral line along the two lines of sight A and B:

(a) In the case when $T_{cloud} < T_{source}$
(b) In the case when $T_{cloud} > T_{source}$

Explain briefly the rationale for your answers.

2) The Planck function describing the intensity of blackbody radiation is:

$$B_\nu = \frac{2h\upsilon^3}{c^2}\frac{1}{e^{h\upsilon/kT}-1}$$

Derive an approximate expression for B_ν valid in the regime where $h\nu << kT$ (hint: you want to approximate the exponential). Write down an expression valid in the opposite regime where $h\nu >> kT$.

3) A cluster of galaxies contains gas at a temperature of $T = 10^8$ K. The gas radiates bremsstrahlung radiation with a luminosity of $L = 5 \times 10^{44}$ erg s^{-1}. By assuming that the gas can be modeled as a uniform density sphere of hydrogen with radius $R = 2 \times 10^{24}$ cm, calculate:

(a) The number density of electrons in the cluster n_e
(b) The total mass of the gas in the cluster in units of Solar masses
(c) If, more realistically, the gas is denser near the center of the cluster and less dense further out, is the true mass of the gas larger or smaller than your estimate in part (b)?