AST 300B – Spring 2019

In-class Problem Due: Fri. Feb. 22

(SEE BACK for parts e & f – 2 pages)

24. Let's analyze the SED of thermal free-free emission observed toward a HII region with a temperature T.

(a) Given the expression we derived for the emissivity coefficient for free-free radiation, derive the equation for the absorption coefficient for free-free radiation from a ***thermal*** plasma. (Hint: what can you assume the Source function is equal to?).

(b) How does α_ν vary with ν and T in the Rayleigh-Jeans limit?

(c) The Emission Measure (denoted "EM") is defined as the integral of the product of electron and ion densities ($n_e n_i$) along the line of sight (typical quoted units: pc cm^{-6}). Show how τ_ν varies with EM, ν, and T in the Rayleigh-Jeans limit.

(d) Now write down the 1D solution to the radiative transfer equation assuming that the Source function is constant along the line of sight through the HII region. Ignore the background. If the HII region has a solid angle of Ω, how does the observed flux density vary with ν (assume Rayleigh-Jeans limit still applies and $F_\nu \sim I_\nu \Omega$) when the emission is in the limits of optically thick and optically thin?

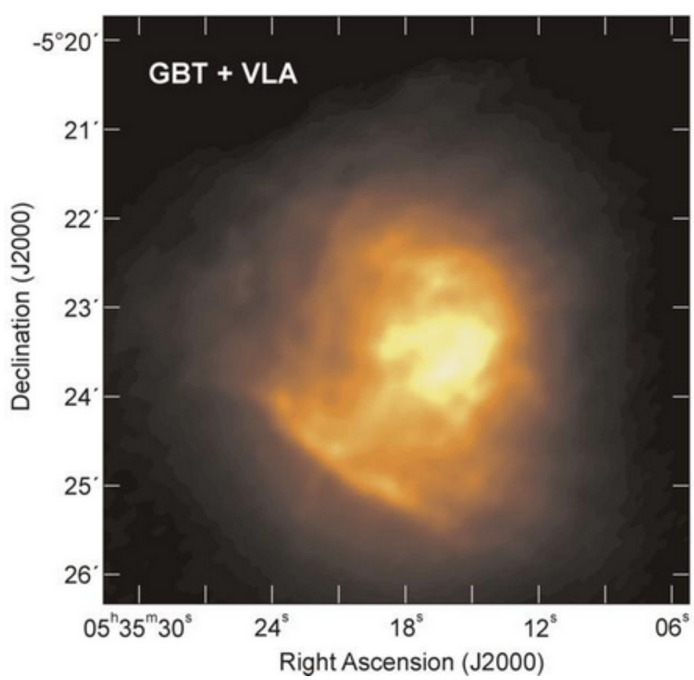

Figure 1: Thermal free-free emission from the Orion Nebula (M42) observed at 8.3 GHz (3.6 cm – called "X Band" in the radio).

(e) On the plot below, indicate the frequency regions where the emission is optically thin and optically thick and the spectral indicies α ($F_\nu \sim \nu^\alpha$) in those limits (quote numbers). Also indicate approximately where $\tau_\nu \sim 1$.

(f) Observations of a HII region indicate that it has a observed flux density of 100 Jy at 400 MHz. If the emission extends over a circular region of diameter ~6 arcminutes, estimate the temperature of the electrons in the nebula. Assume its spectrum has a similar shape to Figure 2.

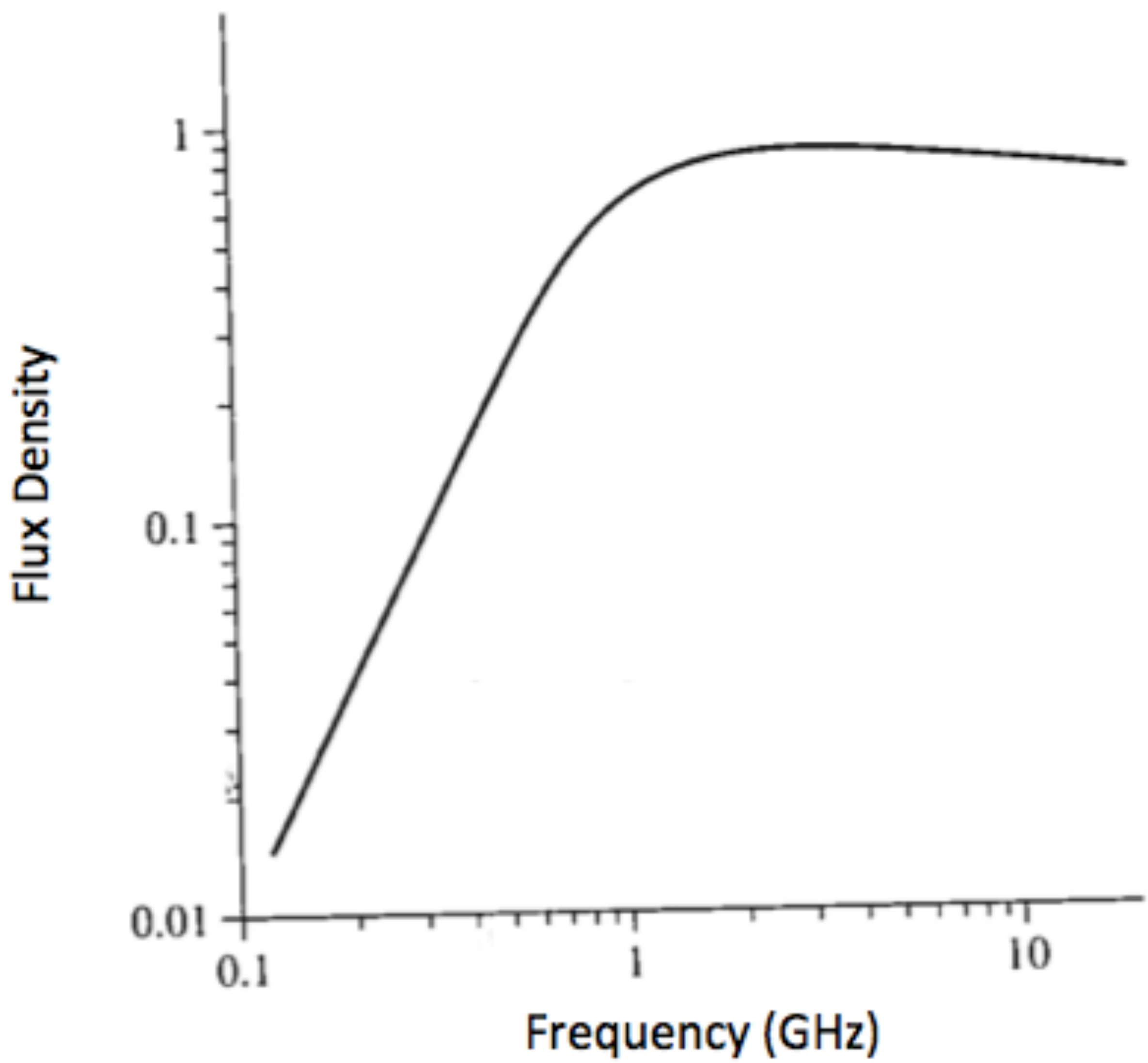

Figure 2: A typical SED of thermally emitting free-free emission from a HII region.