AST 300B – Spring 2019

In-class Problem Due: Fri. Mar. 1st

22. Let's calculate the type of O star powering a HII region from radio emission. It will be helpful in this problem to only plug in numbers at the final step. Draine's book (equations therein) will be very useful…

(a) The Orion Nebula is measured to have a continuum flux density of 495 Jy at 1.4 GHz with spectral index $\alpha \sim -0.1$. The Orion Nebula has T = 9000 K and is located at a distance of D = 414 pc. Write down an expression relating the flux density F_ν from free-free emission to the emissivity coefficient j_ν, the distance to the Orion nebula (D), and the volume of the Orion nebula (V). [HINT: we've done this problem before a couple of times now. Assume spherical geometry.]

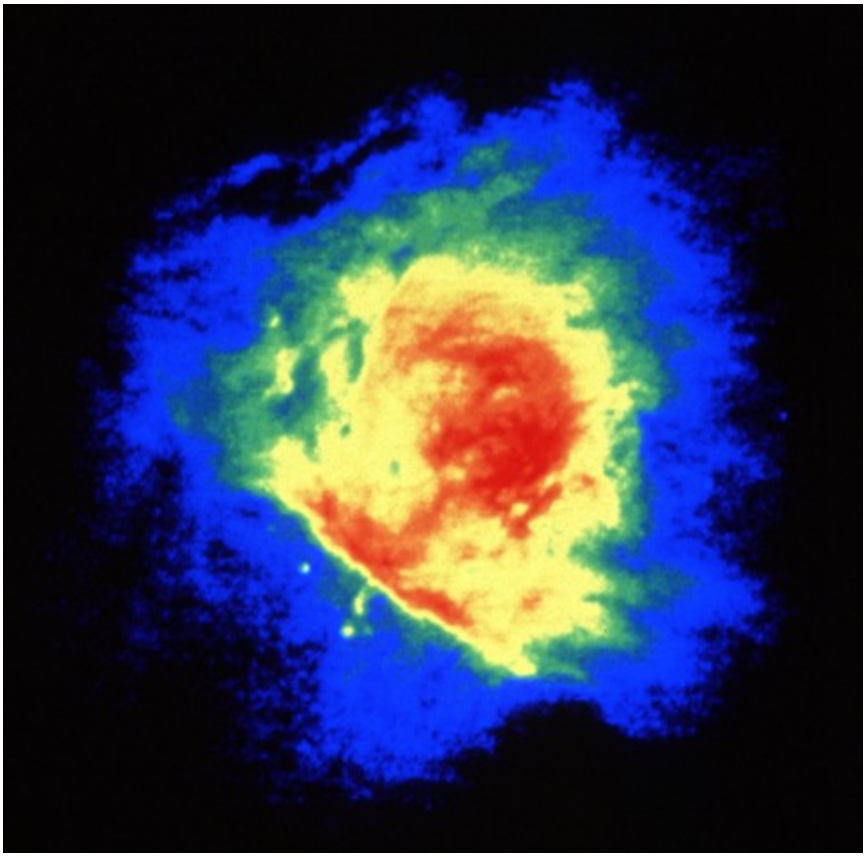

Figure 1: The Majestic Orion Nebula observed with the VLA at 1.4 GHz.

(b) The emissivity coefficient for free-free emission depends on $n_e n_i$. Using your expression above and what you know about the balance of ionization and recombination in HII regions, derive an expression relating Q_0, the number of ionizing photons s^{-1}, to the flux density from free-free emission. [HINT: the number density of protons is related to the number density of ions by $n_p = n_i/1.1$ because the number density of Helium is $n(He^+) = 0.1\ n(H^+)$.]

(c) Now plug in the numbers and calculate Q_0 and determine which spectral type main sequence star dominates the ionization of the Orion Nebula. There are HII regions where you cannot observe the central O stars at optical wavelengths and thus unable to get a spectral type – this method allows you to use the radio continuum to determine the type of star (or how many O stars are) powering the nebula.

Figure 2: W40, a HII region that is the same ~ size and distance as the Orion Nebula, but is obscured by dust and difficult to observe at optical wavelengths because the HII region is on the back side of its molecular cloud from our point of view – it's for this reason you've probably never heard of it! This is an infrared and x-ray image (Red 8μm, Green 5 μm, Blue 0.5-8.0 keV). Westerhout 40 is in the direction of Serpens.