ASTRONOMY 405, Spring 2013

Homework 12, due on April 29

1. Calculate the temperature of a dust grain at a distance of 1 pc from an O6 star, which has an effective temperature of 40,000 K and a radius of 10 $R_\odot$. Assume that the dust grain is spherical with a radius of 1 μm and an albedo of 0.5. The dust grain absorbs the star light, has a uniform temperature, and emits like a blackbody. What is the temperature of the dust grain? Use Wien's law ($\lambda_{max}T = 0.29$ cm K) to determine the wavelength of the peak emission (λ_{max}). Do you see any problem in the dust grain emitting at this wavelength?

2. An ionized expanding shell is observed in an HII region. High-dispersion spectra of the [S II]$\lambda\lambda$6716, 6731 doublets show that the intensity ratio of λ6716/λ6731 is 0.85 in the shell and 1.2 in the surrounding HII region. The spectra also show that the shell is expanding at 250 km s^{-1}. What is the shock velocity? What is the post-shock temperature? Is this an adiabatic shock or isothermal shock?

3. The central cavity of the superbubble N51D (see the left panel of the figure) is filled with hot diffuse gas with density 0.03 H-atoms cm^{-3} and a temperature of 2.3$\times$10^6 K. Within the interior of N51D, a pair of dense concentrations of gas, two Bok globules, have been revealed by a *Hubble Space Telescope* (*HST*) observation of the Hα emission (right panel). The *HST* image shows that in each case the dense material is in a region $\sim$1.5 pc in diameter and enveloped by ionized gas with Hα surface brightness of $\sim$2.9$\times$10^{-14} erg cm^{-2} s^{-1} arcsec^{-2}. The *Spitzer Space Telescope* has also shown that there is emission from warm dust at the location of each globule. The heating sources for this warm dust are believed to be newborn stars embedded in the dust cocoons.

   (a) The ionized surface of the globule is emitting Hα, what is a reasonable temperature to assume for this region? Use the surface brightness of the Hα emission to estimate the density of the gas in the ionized surface layers.

   (b) Estimate the pressures from the following regions: 1) the hot gas in the cavity of N51D, 2) the gas making up the ionized surface of the globules, and 3) the dense gas in the globule itself (globules within our galaxy have typical temperatures and densities of $\sim$100 K and $\sim$1000 H_2-molecules cm^{-3}).

   (c) Is the star formation triggered by external pressure or has the star formtion occurred spontaneously due to gravitational instability? (Hint: calculate the Jean's length and compare to the physical size.)

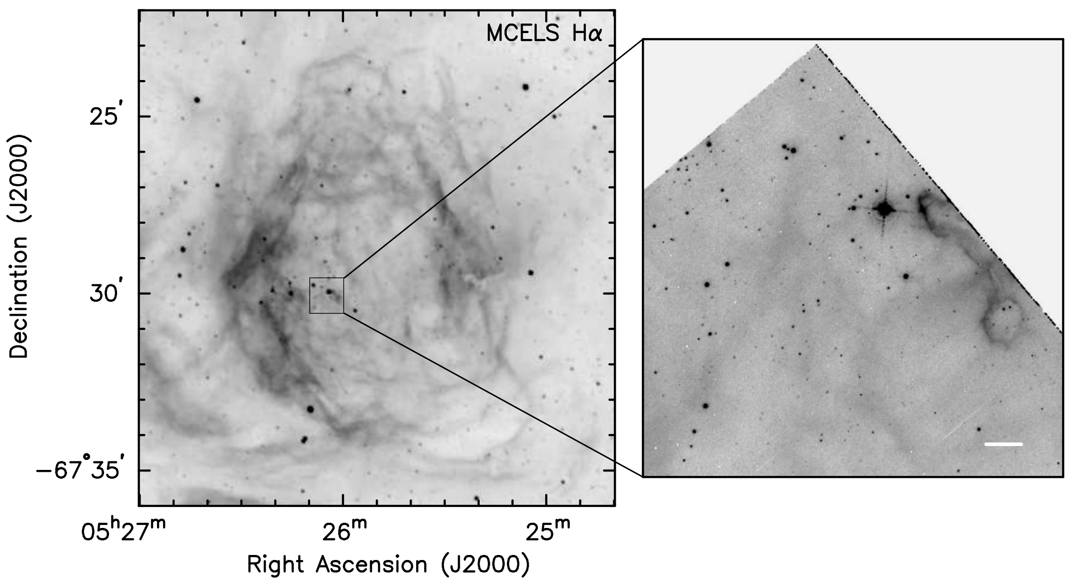

Figure 1: *Left*: A ground based image of the Hα emission from the superbubble N51D. *Right*: a portion of an *HST* Hα image showing two Bok globules (near the right edge of the panel) that are immersed within the superbubble interior. The white line segment in the lower right corner corresponds to a linear size of 1.5 pc.