Assignment #5: due June 12

1. **Types of ionization front**

   Explain, in your own words, the difference between:

   (a) An R-type ionization front and a D-type ionization front

   (b) A strong ionization front and a weak ionization front

   Note: credit for this question will be given for answers that demonstrate physical understanding, rather than simply parroting the formulae discussed in the lecture.

2. **Growth of an H II region in a non-uniform density distribution**

   Consider a massive star producing $\dot{N}_{\rm ion}$ ionizing photons per second that is located at the centre of a static cloud of pure hydrogen with the following number density distribution:

$$n(r) = \begin{cases} n_c & r < r_c \\ n_c \left(\frac{r_c}{r}\right)^2 & r_c < r < R \\ 0 & r > R \end{cases} \tag{1}$$

   Describe qualitatively how the ionization front will evolve if:

   (a) $\dot{N}_{\rm ion} \gg \alpha_{\rm B} n_{\rm c}^2 r_c^3$.

   (b) $\dot{N}_{\rm ion} \simeq \alpha_{\rm B} n_{\rm c}^2 r_c^3$.

3. **H II region trapping**

   Suppose that an O-type star has formed in the centre of a spherical cloud of pure hydrogen that is inflowing onto the star with a constant velocity v and a total mass accretion rate $\dot{M}$.

   (a) Assume that the inflow is in steady state. Show that in this case, the radial density distribution is given by

$$\rho(r) = \frac{\dot{M}}{4\pi v r^2}. \tag{2}$$

   (b) Show that if the number of ionizing photons produced per second by the O star, $\dot{N}_{\rm ion}$, is less than a critical value $\dot{N}_{\rm ion,crit}$, then the expansion speed of the ionization front is less than the inflow velocity v, meaning that the ionization front is trapped close to the star. *Note: for simplicity, ignore any absorption of the ionizing flux within the ionized gas.*

   (c) Compute $\dot{N}_{\rm ion,crit}$ for the case where $\dot{M} = 10^{-3}\,{\rm M_\odot\,yr^{-1}}$ and $v = 2\,{\rm km\,s^{-1}}$.