ASTR 4017/8007, Practice Problems, 29 April 2021

1. When massive stars are forming, the dense flows of gas around them sometimes absorb all the ionising photons close to the star, casting a shadow into a region that had previously been photoionised.

   (a) Consider gas that suddenly finds itself shadowed in this way, and a a result begin to recombine. Is it ever plausible that we would see the ionisation state change within human-observable time scales? If so, under what circumstances (i.e., what sort of properties would the ionised gas have to have)?

   (b) In addition to recombining, the gas will cool. Which happens faster? Recombination, or cooling? In other words, do you expect to ever find cold but still-ionised gas? Warm but already-neutral gas? If so, under what circumstances?

2. Suppose that an ionising star of ionising luminosity Q_0 and total luminosity L forms at the centre of a cloud where the density is not uniform, but instead varies as $\rho(r) = \rho_0(r_0/r)$ for some ρ_0 and r_0. The star produce an H II region that begins to expand.

   (a) Derive a similarity solution for the radius of the ionised region as a function of time, under the assumption that the expansion is driven purely by gas thermal pressure.

   (b) Repeat the calculation for an H II region driven by radiation pressure.