Early and late stellar evolution, part III: Star Formation

Problem set 1, May 22, 2008

All problems except those marked (*) are compulsory for pass. Problems marked with (*) are for higher grades. Please motivate your answers carefully (when applicable). There will be 3 problem sets in total, for this part of the course. A report containing the solutions to these problem sets should be handed in **no later than 2008-06-20, 24:00** for grades higher than pass. The report can be submitted on paper, or as a PDF sent to `alexis@astro.su.se`, or both (as long as the versions are identical). If submitted only in paper form, still send an email notifying that the report has been submitted. Note that not all problems are explicitly treated in the lectures; most are in the Stahler & Palla book, however.

1. Verify that the line source function

$$S_\nu = \frac{2h\nu_{ij}^3}{c^2} \frac{1}{\frac{n_i}{n_j}\frac{g_j}{g_i}\frac{\phi_\nu}{\psi_\nu} - 1}$$

   in thermal equilibrium is given by the Planck function, assuming complete redistribution ($\phi_\nu = \psi_\nu$).

2. Describe briefly in a written report how to determine *empirically* some basic cloud parameters:
   (a) How to detemine the *distance* D to a cloud.
   (b) How to detemine the *mass* M of a cloud.
   (c) How to detemine the *extinction* A_V of a cloud.
   (d) How to detemine the *pressure* P of a cloud.
   (e) How to detemine the *rotation* Ω of a cloud.
   (f) How to detemine the *age* t of a cloud.

3. * Fig. 1 shows the resolved optically thin emission profiles coming from H I and O II in a region of an instellar cloud.
   (a) What is the gas temperature of the region?
   (b) What is the "turbulent" velocity?
   (c) Assuming the region is of characteristic radius 10 pc and mass $10^4\,M_\odot$, is the thermal and turbulent support enough to prevent the cloud from collapsing?

4. * Assume a spherically symmetric hydrogen cloud core, illuminated only by the interstellar radiation field (ISRF) approximated by a blackbody of 10 000 K diluted by a factor 10^{-14}.

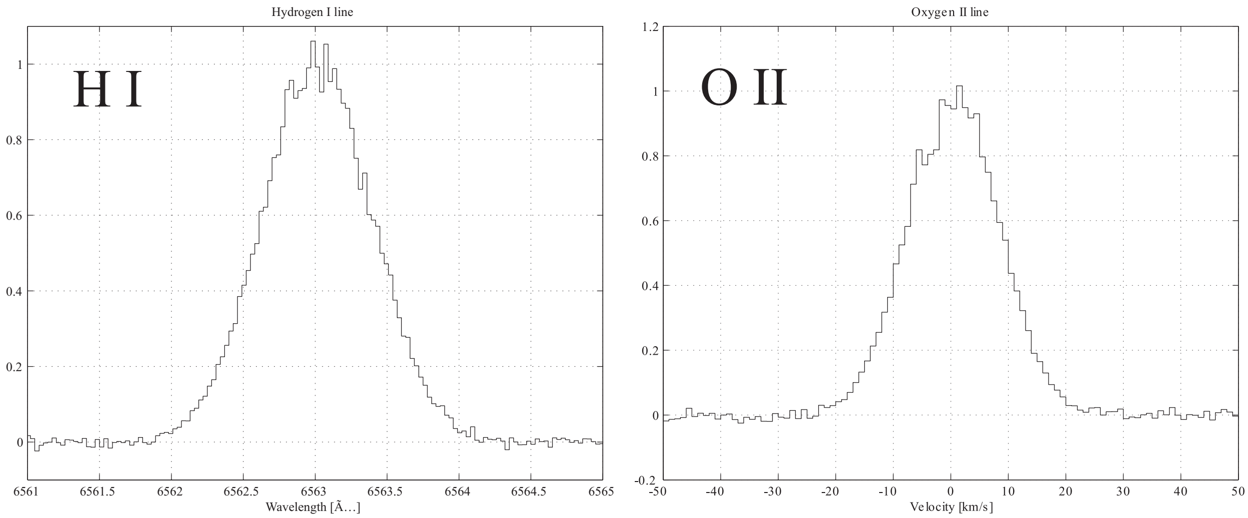

Figure 1: Emission lines from an interstellar cloud.

(a) If the core is of constant H-nucleus density n_{H}, how thick ΔR is the H II layer due to ionisation by the ISRF? For simplicity, use a Strömgren-like approach where there is a sharp boundary between the H I and H II regions, all ionising photons get consumed, and the recombination coefficient is $\beta_2 = 2 \times 10^{-19}\,\mathrm{m}^{-3}\,\mathrm{s}^{-1}$. Estimate ΔR for some typical n_{H} of dark cloud cores.

(b) If the number density of the outer part of the cloud is not constant, but scales as a power-law

$$n_{\mathrm{H}}(R) = n_0 \left(\frac{R}{R_0} \right)^{-\alpha},$$

with $\alpha > 3$, what is ΔR? Compute ΔR for some typical cases.