

The Interstellar Medium

Problem Set 4

Due **in class** Wednesday February 2, 2011

Readings: Chapter 7 of Tielens.

Homework Problems:

Spectra of H II regions

1. Consider an HII region heated by photo-ionization of H and cooled through emission by transitions of [OIII]. Solve the energy balance equations (7.59)- (7.61) and show that the electron temperature is approximately 7000 K under the assumptions used in these equations.
2. Solve the energy balance for the HII region in the previous exercise assuming an [OIII] abundance which is a factor of 3 higher. [Hint: for simplicity, treat each of the [OIII] fine structure levels as a two level system (cf., Eqn (2.30)). Relevant parameters are given in Table 2.6]. *Assume that the ionizing star has the same temperature.*
3. Estimate what happens to the ratios $[\text{O III } \lambda 4363]/\text{H}\gamma$ and $[\text{O III } \lambda 5007 + 4959]/\text{H}\beta$ if you *decrease* the [O III] abundance, again assuming that the ionizing star has the same temperature.
4. In class we didn't discuss Emission Measure. To make up for this deficiency derive Equations (7.63) and (7.64) from equation (7.62).
5. Nor did we discuss radio emission from H II regions, so to make up for this derive Equation (7.71). Use Equation (7.68) to write an expression for the radio emission in the high and low optical depth limits in terms of the electron temperature, emission measure and frequency. Sketch the radio spectrum for an emission measure of 103, 106, and 109 $\text{cm}^{-6} \text{ pc}$. Explain your result.
6. Describe how the observed spectra of HII regions can be analyzed to determine the physical characteristics of the gas and ionizing star.