UE7b: Evolution of Galaxies
Homework (return before Christmas)

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1 Spectra of HII Regions

Let us pretend that you have done spectroscopic observations of a couple of HII regions, and now you wish to determine the chemical compositions of these objects. Each one of you has three spectra, whose lists of measured line intensities you download from the UE7b website: `http://astro.u-strasbg.fr/ koppen/ue7b/` To interpret the data, you will use the applet `http://astro.u-strasbg.fr/ koppen/nebula/Plasma.html`
Because the spectra were actually computed from photoionization models, we can directly compare the results of the plasma diagnostics analysis with the abundances that had been assumed in the models! Our main interest is to find out the errors of the analysis and how these errors vary among the elements as well as how they depend on the parameters of the HII region: the central star and the density of the gas.

The top part of each data sheet gives the model input parameters, such as the temperature and radius of the central star and the the nebula density (in atoms per cubic metre) and the abundances of the gas (in the usual $12 + \log$ values); the bottom part is the spectrum, giving for each line the identification, the wavelength, and the intensity. Intensities are measured on a scale relative to $I(H\beta) = 100$, as is often done in real nebular observations. [The "transition" is an internal code in my program, which identifies the element, ion, and transition: e.g. the [O III] 4363Å line is from level 5 to 4 in the O^{++} ion, hence 803.450]. Please note that for the two multiplets of [O II], the line marked by "B" already gives the sum of the components. This is what you enter in the applet. Some of the data sets list more lines than you need; use only the lines of the correct wavelength requested by the applet.

Since the theoretical spectra do not need the correction for interstellar reddening, click the Button "Extinction c" to set this parameter to a constant value, and enter the value 0.0.

- for all spectra and all elements, compute the differences between the derived abundances and the assumed model values.
- how do these differences depend on the stellar temperature? Make a plot for each element of these deviations as a function of the temperature of the central star. For which elements do you get more accurate values? Do the errors show any systematic behaviour? If you like, you could combine your results with those of your colleagues! It might give a more complete picture.

- some of the lines are quite weak: it would be extremely difficult to get spectra with line whose intensities are less than a few percent of Hβ. So, what would you get, if you set line intensities below either 1 or 5 percent of Hβ to zero?

- now, put back in those weak lines ... often, the [SII] lines are not very strong: how do the results change, if you simply fix the density at a reasonable value: any realistic HII region would surely be in the range between about 1 and 10000 cm^{-3}!

- the temperature-sensitive lines [OIII] 4363 and [NII] 5755 can be quite weak: Change their intensities by a factor of two (up and down) and see how much this changes the abundances. Which line is more crucial? What error in these lines could you accept, if you demand an accuracy of 0.1 dex, say, in the logarithmic abundance (i.e. a factor of 1.25 in the linear abundance value)

- in the paper by Yin et al. (2007, A&A 452, 535) you'll find a compilation of a number of strong-line methods, including the two versions by Edmunds & Pagel, MNRAS **211**, 507 (1984), and Pilyugin's method, A&A **362**, 325 (2000). They allow to derive the oxygen abundance from the [O II] and [O II] lines. (Note that the intensity of the [O III] 4959 and 5007 lines are strictly linked by I(5007)/I(4959) = 2.88) There is also the method proposed by Stasińka (2006, A&A 454, L127) based on [ArIII] and [SIII]. Try them out and compare them! What's your opinion?