Identifying Emission Lines

The Templates page contains a set of spectra labelled with the wavelengths of emission lines seen in planetary nebulae and identifying the ion producing each emission line. The name of the element is given using the standard chemical symbol from the periodic table (e.g., H=hydrogen, N=nitrogen, Ne=neon, etc.). The ionization state of the element is indicated by a Roman numeral suffix in the following way: neutral=I, singly ionized=II, doubly ionized=III (i.e. ionization state = Roman numeral -1). For example, O III means doubly ionized oxygen, O^{+2}. Certain electron transitions involve energy levels that are said to be *metastable*; the resulting emission lines are called *forbidden lines*, which really only means that they are less likely to occur than emission lines from the ordinary kind of transitions. Conditions in planetary nebulae, as it turns out, are extremely conducive to the production of this kind of emission line, and in fact, most of the emission lines you will see in these spectra are forbidden lines, which are denoted by brackets around the ion designation (i.e. a forbidden line produced by doubly ionized oxygen would be written as [O III].

The Exercise

You may find it helpful to print out this page of instructions.

Listed below are three planetary nebulae whose central stars have very different temperatures. You will examine the spectra of each nebula and by noticing the presence or absence of certain emission lines, be able to rank them in order of the temperature of the central star.

M1-57 IC 3568 NGC 6210

1. Print out the data table for this exercise. Notice that there is an identical table for each planetary nebula, containing a selection of forbidden lines produced by highly ionized atoms in the nebular gas. The first column gives the wavelength of the emission line, and the second identifies the element and the ionization stage. The third column lists the ionization potential of the preceding ionization stage. For example, for [K IV] (which means K^{+3}) the relevant ionization potential is that of K^{+2}, since we are interested in the energy required to ionize K^{+2} one step further to K^{+3}.Click on the name of one of the planetary nebulae above; this will take you to its spectrum display. Expand the spectrum around each of the wavelengths listed in the data table, and look for that particular emission line. Note its absence or presence and fill in the appropriate table. Because of the relative motion between the Earth and each nebula, the wavelengths may be Doppler-shifted slightly from their nominal values. If you are not sure whether the line is really there, write "?" in the table.
2. Repeat for the other two nebulae.
3. Examine each table. Of the elements producing emission lines that you detected, note which has the highest ionization potential, meaning which element requires the most energy to reach its observed ionization state. The higher the maximum ionization potential, the hotter the central star must be.
4. You can now rank these three planetary nebulae on that basis. Fill in the "results" portion of the data table in descending order of stellar temperature.
5. You might want to search the literature for determinations of the stellar temperatures for these planetary nebulae to see if your relative ranking is correct. And you also might like to try this for some of the other nebulae on the Browse page.

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