ASTR 288C - Astronomy Research Techniques

Fall 2019

Homework Assignment No. 4

1. In the notes to lecture 4, we gave an expression for the ratio of the emission in line $2 \Rightarrow 1$ compared to the emission in line $3 \Rightarrow 1$ as a function of temperature. Let's look at this for the [O III] lines, where we lump the fine structure levels into one level (n=1), but consider the ratio of $2 \Rightarrow 1$ compared to the $3 \Rightarrow 2$ (λ4363) transition. (The $3 \Rightarrow 1$ is at λ2322 in the far UV.) See Figure 4.3 in the notes. Here are the values for this ion:

   Statistical weights: $g_1 = 9 \quad g_2 = 5 \quad g_3 = 1$

   Energy in eV: $E_{12} = 2.51 \quad E_{13} = 5.35$

   Collision strengths: $\Upsilon_{21} = 2.29 \quad \Upsilon_{31} = 0.29$

   Radiative decay rates (/sec): $A_{21} = 0.0268 \quad A_{31} = 0.23 \quad A_{32} = 1.6$

   (a) We mentioned that our expression did not consider the *branching ratio* for decays out of level 3. From the decay rates given (the A values, called *Einstein A-values*), what is the branching ratio?

   (b) Modify the equation for R in the notes to apply to the case of [O III],
   $$R = \frac{j(\lambda 5007 + \lambda 4959)}{j(\lambda 4363)}.$$
   Include the branching ratio.

   (c) Write out the expression for R, putting in all the numerical values for O III. If we observe $R = 60$, what temperature does this equation yeild? How does this compare to the result shown in the Figure 5.1 in the lecture notes?

2. We looked at the planetary nebula NGC 7027 in the last problem set. Display it again using the routines in the IDL language.

   (a) You see two circular arcs outside the nebula (and also a faint third one further out). Use the idl proceedure fit_circle.pro to locate the center of the arcs and their radii.

   (b) Download an HST image of the nebula NGC 6543 in a strong line like Hα. Display it so you can see one or more outer arcs. Measure their radii and the location of their centers. Do the centers nearly coincide with the central star?

Due: 7 October 2019