UNIVERSITY OF CALIFORNIA, SANTA BARBARA
Department of Physics

Physics 233 **Presentation II (Due Fri. March 14)** Winter 2014

In this assignment, you will complete a photoionization calculation of your choice using a computer program named *Cloudy*. *Cloudy* is designed to simulate conditions in interstellar gas under a broad range of physical conditions. Its origins lie in a postdoctoral project led by Gary Ferland in Cambridge (UK) in the 1970's, but additional physics has been continuously added right up through the 2013 release of Version 13.

The material we have covered in class provides you with a background similar to that which the typical astrophysicist possesses when he/she uses *Cloudy* for the first time. Ten days is not enough time to fully explore and understand everything *Cloudy* does; no way. Your goals are to (1) become familiar with what *Cloudy* can calculate, (2) get the example calculations running, and (3) run a calculation of your choice for which you think you know the answer.

Please hand in a 1 to 2 page paper that contains the following information:

- **What do you want to calculate?** You should describe the initial conditions including the geometry of the calculation (usually a plane parallel slab of gas). You should specify the spectral energy distribution, the ionization parameter, and the composition of the gas. You should define the stopping criterion for the calculation.

- **What result do you expect?** The answer could be an analytic solution to a similar, but simplified, problem. It could, alternatively, be a plot or table from a published paper which you simply wish to reproduce. You must have some expection, in any case, of what your result should look like.

- **Discuss your result.** Start with a few sentences about why you choose this calculation, and then answer the following questions. Did anything about the result surprise you? If so, were you able to understand in hindsight why the result differed from your initial expectations?

The paper that you turn in may include a third page containing figures or tables. I am encouraging you to condense the output into a single plot or table. Get to the scientific point; there is no need to turn in the entire Cloudy output.

You'll have 5 minutes to present your results to the class on March 12th. I recommend you again address the three questions listed above. *Please Note. In the (unlikely, put possible) event that you don't get sensible results, you can still answer many of the questions stated above. My hope would be that you would gain insight into what may have gone wrong by listening to the other presentations and asking questions.* As before, if using the projector, please email me your pdf file no later than 11 am on March 12th.

Step by Step Guide to Getting Started with Cloudy

1. Scan through the review article titled *THE 2013 RELEASE OF CLOUDY*. I have a link on the class web page, and the identifier is arXiv:1302.4485.

2. Point your browser at the Cloudy homepage:

   `http://www.nublado.org/`

   . Click on the link **StepByStep** instructions. Complete Steps 1 through 5. You can skip Step 6 for this class exercise. Step 7 will be required for many, but not all, calculations. You will want to complete at least a few tests from Step 8. Since you do not need to produce publication quality results by March 12th, you may postpone going through Steps 9 and 10 (until such need arises). (FYI, I have sucessfully installed and tested Cloudy 13.02 under OS X 10.6 and OS X 10.8. Let me know this week if you do not have access to an appropriate computer for code installation.)

3. Congratulations on getting over the hurdle of installing the code. The easiest way to learn how to set up a calculation is to toggle back and forth between the example calculations and **Part I** of the manual (Hazy) which is included in the installation:

   `../c13.02/docs/hazy1_c13.pdf`

   .

SUGGESTED TOPICS FOR PRESENTATION

Realizing that picking a calculation may be hard if you do not have much research experience yet, I provide some examples below. If you want to use one of these examples, then please email me to confirm that no one else has selected the same exact problem. In general, keep things simple for this exercise since you don't have a lot of time; and please come talk to me if you are not sure how much to undertake.

- **Example: Expand on a HW Exercise.** Compute the ionization structure of an HII region around (1) an O6 star and (2) an B0 star. Assume a homomegeneous ISM containing H and He (and/or the cosmic abudance ratios of heavier elements). Compare the ionization fraction as a function of radius to Figure 2.4 in Osterbrock's book. This satisfies the requirements of the assignment. To make it more interesting, you could predict and verify/refute how adding dust to the HII region changes the Stromgren radius.

- **Example: Verify a result from one of our textbooks.** Figure 5.3 of Osterbrock shows the ratio of the [SII] 6717 to [SII] 6731 flux from HII regions as a function of electron density. You know how to compute the low and high density limits and the density range where the ratio changes rapidly with electron density.

- **Example: Reproduce a published result.** See, for example Figure 4 in Murray et al. 2007, ApJ 660, 211. The dashed line is an analytic result for the Na ionization fraction in a galactic wind. You could recompute the values of the open triangles, perhaps with a simpler SED.