ASTRONOMY 8300 – FALL 2024
Planetary Nebula Project
Due 12/9/24 at 9:30 AM

This is a research project to analyze the UV/optical spectrum of a planetary nebula (PN) observed by the Hubble Space Telescope (HST)/ Faint Object Spectrograph (FOS). Images from HST (see above) show that the PN, NGC 6833, is compact and somewhat elliptical in appearance, with a maximum angular diameter of 0.8 arcsec. The FOS aperture used was a square with sides of length 4.3 arcsec, so the entire PN was included in the aperture. The distance to this PN has been estimated to be 4750 pc.

To analyze the spectrum, get into IUE IDL (see the handout) and load the spectrum by typing:
IUE_IDL> restore,'/nfs/morgan2/crenshaw/ngc6833.dat' (may need to type this out rather than cut and paste)

The wavelengths are stored in a vector called "wave" and the fluxes are in a vector called "flux". You can use the IDL commands in the handout to analyze the spectrum.

1. a. (10pts) Make hard copies of the spectra at suitably expanded scales and label as many emission and absorption lines as you can identify. Note that some lines may be blended, and there may be a few weak instrumental artifacts. Not all lines on the list for Seyfert galaxies will be detected, and there will be some lines in the PN spectrum that are not on the list. Other sources of lines are publications on PN, and the CLOUDY output for a PN model.

b. (5 pts) What absorption lines have you detected, and what are they due to?

c. (5 pts) Examine the large-scale continuum features (over hundreds to thousands of Angstroms). What can you attribute the large-scale continuum features to?

2.a. (5 pts) Measure the emission line fluxes of Hα and Hβ (net fluxes above continuum). Compare the measured Hα/Hβ ratio with that expected for a PN. What is the reddening E(B-V) [hint - use the standard Galactic curve to get the relationship between E(B-V) and $A_\lambda(4861) - A_\lambda(6563)$]?

b. (5 pts) Correct the spectrum for reddening with the IDL command: unred,'',w,f,ebmv,fcor ('' are single quotes, ebmv is the E(B-V) value, and fcor is the corrected flux). How did the reddening correction affect the 2200 Å dust feature?

3.a.. (10 pts) Measure all of the emission line fluxes (from the reddening-corrected spectrum), and make a table of line ratios relative to Hβ.

b. (5 pts) Determine an approximate temperature for the gas, using appropriate line ratios.

c. (5 pts) Determine an approximate density for the gas, using appropriate line ratios.

d. (5 pts) Consider the ionization state of the gas, based on lines that you have and have *not* detected. Compared to other planetary nebulae, is this a high, average, or low ionization PN? What does that imply about the temperature of the central star?

4. Generate a CLOUDY model to match the physical conditions that you have estimated. Input parameters should include the spectral energy distribution, luminosity, inner radius, and density. Use other input parameters (.e.g., column density, geometry, abundances, filling factor, etc.) as dictated by the physical situation or as needed. Compare the output "intrinsic" ratios with the observed (dereddened) values. Generate additional models until a good match is obtained (for at least a majority of the strong lines).

a. (20 pts) Describe the procedure that you used to obtain a good match. List your final model parameters. Include the printout for your successful model.

b. (5 pts) Update your table of line ratios to include the final model values from CLOUDY.

c. (10 pts) What lines are still not matched well? What could be the cause(s) of the discrepancies?

d. (10 pts) Give a brief summary of your results. What have you learned about NGC 6833 and planetary nebulae in general from this experience?