ASTR469: Homework #6.

Due Fe. 24 at beginning of class.

In this assignment we will be working with spectra taken previously in this class of atomic hydrogen (HI) and radio recombination lines (RRLs). The spectra come from an area near the massive star formation region known as W3.

RRLs are from ionized gas. When an electron and an ion recombine, the electron is sometimes left in an exited state. The electron then transitions toward the ground state, emitting radiation at each transition. These lines are seen in emission in all normal circumstances.

1. (1 point each, unless specified otherwise) W3 is at (RA, Dec) = (02:27:04.10, +61:52:27.1). We observed on 2/27/2015 at 3:30PM EST. We observed four positions (see Figure 1), two in W3 ("W3Main" and "W3OH") and two to the south ("HI_1" and "HI_2").
   (a) From an online calculator, what was the LST on 2/27/2015, at 3:30PM EST?
   (b) What was the HA of W3 at 3:30PM when the observations began?
   (c) What was the elevation of W3 when the observations began?
   (d) What was the elevation of W3 when the observations ended 1 hour later?
   (e) (2 points) RRLs (of hydrogen) follow the Rydberg-Ritz formula. For energy level changes of 1 ($\Delta n = 1$), what values of n can we expect at L-band (1-2 GHz)?
2. There are multiple spectra in Figure 2.

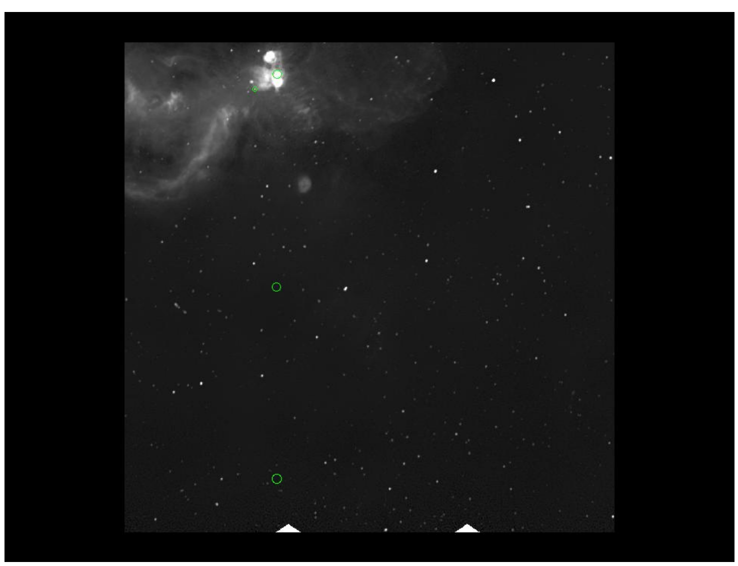

Figure 1: Observed positions (green circles) on a radio continuum image.

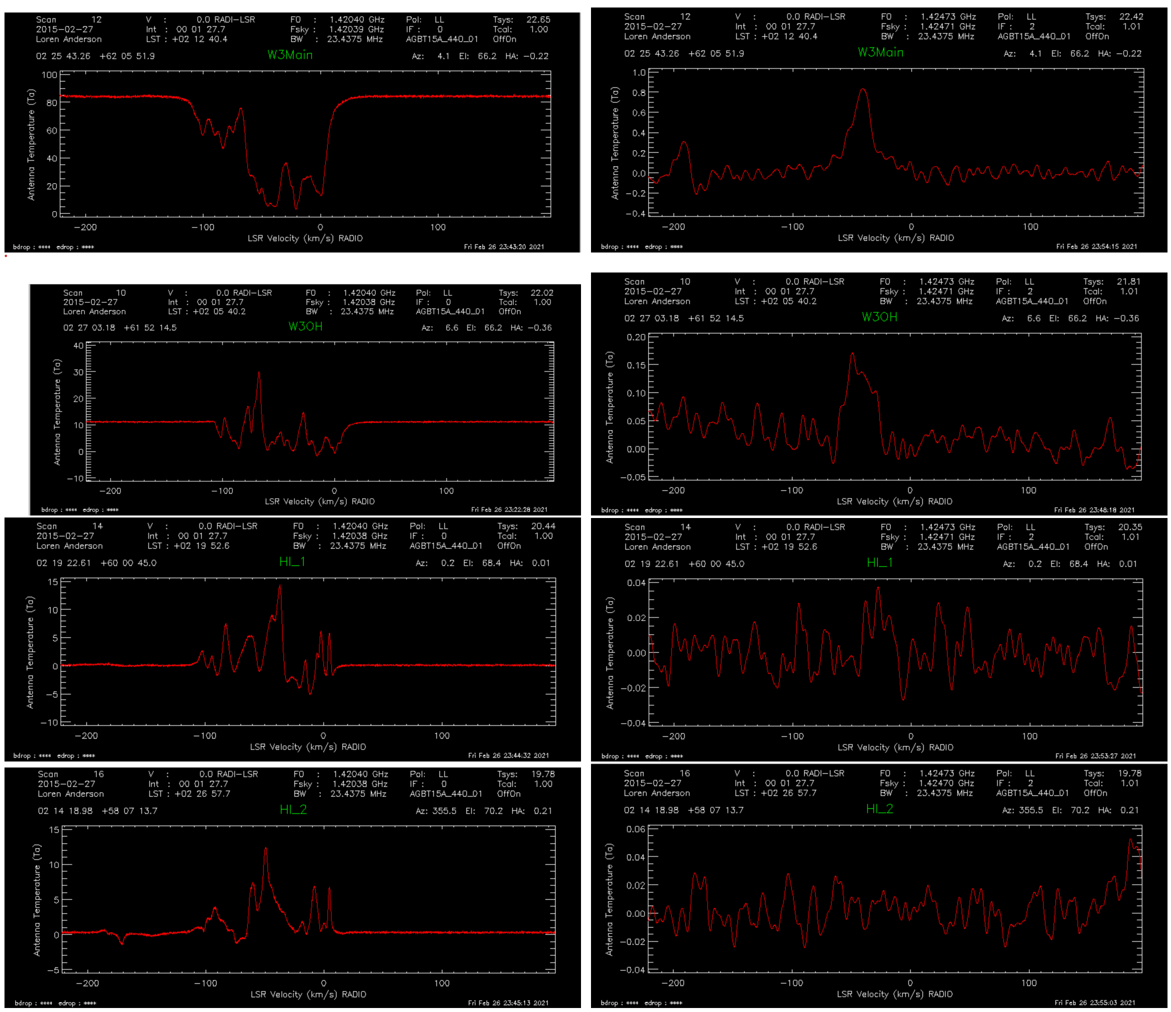

Figure 2: Spectra taken at the four positions. The left column has HI and the right column has a recombination line.

(a) (4 pt) For the two recombination line specta with definite detections, please tell me a) the peak line intensity (in antenna temperature), b) the approximate line width at half the maximum intensity (in km/s), and c) the peak velocity (in km/s). Note that the continuum has been removed from the recombination spectra to make this easier.

(b) (4 pt) Different HI clouds along the line of sight can emit at many velocities. For W3 we find HI at velocities from about -100 to $0\ \mathrm{km\,s^{-1}}$. For the HI spectra, interpret them in the context of Kirchoff's Laws. The continuum has not been removed, which is an important part of the interpretation. I want to know why some show HI absorption and some show HI emission, and why the strength of absorption varies between positions. Why, for W3OH are some portions of the spectrum in absorption and some in emission?

3. (2 pt) What temperature would a blackbody have to be to produce emission that peaks in the radio band (e. g. 5 GHz)?

4. (4 pt) About two decades ago, the HALCA satellite was launched to enable interferometry from space at wavelengths of $\sim$30 GHz. It formed baselines using dishes from the Very Long Baseline Array, which spans North America. HALCA's highly elliptical orbit had an apogee distance of around 26,000 km from Earth's center. What is the smallest linear scale this experiment could have measured for an object at the distance of the Andromeda galaxy, about 800 Mpc away?