ASTR 302

Homework 5: Due April 26, 2024

You are welcome to use any resources available to you, and are free to discuss the homework with other students. Collaborative studying is encouraged, but the write-up you turn in should be your own. Please neatly write or type your results, showing your work and/or justifying your answers with equations (i.e. don't just use your computer to calculate the answer and then only give the result).

1. Describe the advantages and disadvantages of the following spectrographs: a) Slit-fed single object (e.g. NIRSPEC); b) Fiber-fed Multi-Object with a few hundred fibers (e.g. APOGEE); c) Fiber fed integral field unit with thousands of fibers (e.g. VIRUS). Give an appropriate science case for each.
2. You are designing an imager for a new 2-meter telescope to be installed on Mt. Lemmon. The typical seeing is 0.8". You are using a CCD with 10 micron pixels. What sampling do you want (e.g., how many pixels per FWHM)? What F# do you require for your overall imaging system.

3. What is meant by the term 'spectral resolution' or 'spectral resolving power'? How does the size of your entrance slit affect spectral resolution? Why would you want (or not want) to use a very small slit, or a very large slit? How is this limited by the pixel size on your detector?

4. Ceres is the largest asteroid, with a diameter of 950km. It is currently 3.8 astronomical units from Earth. Assuming it has a 300GHz (1mm) brightness temperature of 175K, calculate the flux density we will receive from this object at this frequency.

5. The Arizona Radio Observatory telescopes have a summary of their receiver capabilities here: http://aro.as.arizona.edu/sites/default/files/AROstatus30Jul2019-compressed.pdf
   Assume that you want to observe two transitions of the same molecule, one at 115GHz and one at 345 GHz.
   a) Which telescope and receiver will you use to observe each transition?
   b) If you need to measure the spectrum of these lines with 0.5 km/s resolution, and you take your data with the best possible system temperature (Tsys), how long does your integration time need to be for each transition in order to obtain a spectrum with a noise of 10mK (milli-Kelvin, i.e., 0.01K).