Astronomy 423 Homework Set 2

Due: Wednesday, Feb 10

Remember to show your work!

1. (a) What is the flux density (in Jy) of a source that radiates a power of 600 W in the radio frequency band uniformly from 2.7 to 2.8 GHz, when placed at the distance of the Moon? (b) Repeat for an identical source if the radiation is in the optical frequency band, from 375 nm to 1000 nm. Recall 1nm = 10^{-7} cm.

2. (a) How much power (in Watts) is delivered to a receiver at the Green Bank telescope, a 100 m diameter telescope (the largest fully steerable radio telescope), when observing the bright radio source 3C286? The bandwidth is 200 MHz wide and the observing frequency is 4500 MHz. You will need to consult the current flux density of this calibrator at https://science.nrao.edu/facilities/vla/docs/manuals/oss/performance/fdscale (b) How many photons will the GBT receive each second from 3C286?

3. A radio source has a flux density of 5.5 Jy at 1400 MHz and has an angular size of 10" x 10". What is the temperature of the equivalent blackbody, that is what is the brightness temperature, T_b, that would give the same flux density?

4. The WMAP satellite has determined that the temperature of the cosmic microwave background (CMB) is 2.73 K. (a) Use Planck's function to determine the brightness of the CMB at a wavelength of 1 mm. (b) Use the value of part (a) at 1 mm and the Rayleigh-Jeans approximation to the Planck function. What temperature do you derive for the microwave background? (Basically, this shows how good/bad the RJ approximation is at this temperature and wavelength). (c) Redo (a) and (b) at 90 cm to find the temperature you would obtain if you measured the CMB at 90 cm? (d) Suppose you had an emitting molecular cloud at T=100 K. Redo part (b) using 1 mm wavelength to see how good the Rayleigh-Jeans approximation is at this temperature.

5. A typical cell phone transmits 200 mW of power at 850 MHz with a bandwidth of 30 kHz. (a) What is the flux (in mW/cm^2) from the antenna at a distance of 5cm? (b) Compare that to the "harmful" threshold set by the FCC of 10 mW/cm^2. Are you in danger from your cell phone? (c) What is the flux density from your cell phone (in Jy) that a 25 m radio antenna 10 km away would see? (d) If signals larger than 10^9 Jy cause gain compression in the receiver, is the antenna safe? (e) How many photons would this 25 m antenna intercept each second?

6. Learning about the astronomical literature. If you aren't already, you should start to become familiar with papers in astronomical journals. During the lectures in the first week I discussed many types of sources that emit in the radio. We will be learning about some of these in more detail but for now I'd like you to explore a little on your own. An excellent resource is the Astrophysical Data Services, ADS (which you should have access to from computers on campus). With the ADS you can find papers of interest and download complete PDF versions. The ADS is at http://adsabs.harvard.edu/abstract_service.html
In the abstract words/keywords section try typing in words such as supernova, pulsar, quasar, blazar, VLA, VLBA, etc.. Select a paper and find out the following information:
Title, Authors, Journal, Publication date, general topic or type of source, telescope used, wavelengths used, general point the paper is trying to address (very general – should be in the abstract. I'm just looking for a one or two sentence description).