Astronomy 423 Homework Set 4

Due: Monday, Feb. 20

1. Calculate the diffraction limited field-of-view (FWHM) for a single VLA antenna in arcminutes at all the frequencies that the VLA operates at (74, 330, 1400, 5000, 8400, 15000, 22200, and 43000 MHz).

2. A typical aperture efficiency for the EVLA at 43 GHz is 35%. (a) What is the rms surface error in mm on an EVLA dish? (b) If the indentation left by someone walking on the surface of the dish can be as large as 0.5mm, is it a good idea to let people on the surface? Actually we can reduce the indentation by walking carefully on the edges of the panels, so if we get the chance, we will.

3. Consider the power output of a cat. Assume that all the energy intake in a day, 300 kcal, all goes into heat and is radiated away, and that no useful work is done (we consider here a day spent napping). Note that 1 kcal = 4185 J. (a) Give the average power output of the day in Watts. (b) At what wavelength (in cm) will the emission be peaked? (c) If you launched your cat into space such that it appeared to be 1 arcsecond across with the VLA, and it kept the same room temperature you used for part (b), what would be its flux density at 3 GHz in Jy?

4. The VLA antennas have a system temperature of 37 K at 1.4 GHz, and an aperture efficiency of 0.5. (a) How bright (in Jy) does a source have to be to have the antenna temperature equal the system temperature (that is, what is the SEFD)? (b) How about for the 305 m Arecibo telescope assuming similar system temperatures and aperture efficiencies? (c) Now calculate the SEFD for an LWA station operating at 50 MHz. Assume that the dipoles have G=3.5 (compared to G=1.5 for a Hertz dipole), and that there are 256 dipoles in a station, and that the system temperature is dominated by the sky temperature, which is 5500 K at 50 MHz.

5. Look up the SEFD for the VLA at 15 GHz from the VLA Observational Status Summary (https://science.nrao.edu/facilities/vla/docs/manuals/oss). (a) Assuming that the aperture efficiency is 0.5, what is the system temperature at 15 GHz? (b) If new receivers were installed that worked at the quantum limit and the other contributions to the system temperature sum to 15 K, what would the new system temperature be? (c) How long would an observation need to be with this new system to reach an rms noise level of 0.19 mJy/beam, assuming that the total bandwidth is 8 GHz, there are 27 antennas, and dual polarization?

6. Suppose that we have an ideal square antenna (constant gain across the aperture) with a diameter that can be described by a box function of width D that is unity between –D/2 and D/2 and zero everywhere else, derive the primary beam of the antenna as a function of angle (θ) from the axis of the antenna surface, and the diameter D. At what angle is the first null (where the response of the antenna goes to zero)?