Astronomy 423 Homework Set 5

Due: Monday, Mar 6

1. A two-element interferometer operating at a wavelength of 100 cm has a separation of 100 meters. Write down an expression relating the geometric delay to the total phase delay of the wave (ϕ). Show that if the waves are coming from a direction 60 degrees from the horizon then an error of 0.1 m in measuring the baseline length will produce an error of 0.1π in ϕ_0 where $\phi_0 = \phi - 2\pi n$ is between 0 and 2π and is the actual phase delay to be applied. Show that a 0.1% error in the baseline length is amplified to a 5% error ($(0.1\pi/2\pi)*100$) in the phase because the separation is many wavelengths.

2. The Arecibo radio telescope in Puerto Rico is a **305** m diameter filled-aperture spherical dish, while the Very Large Array has 27 parabolic dishes each 25 m in diameter with a maximum baseline length in A configuration of 36 km. Calculate the ratios of: (a) total collecting areas, and (b) the angular resolution for the two telescopes. (c) Which telescope might be better for detecting faint sources in a short amount of time, and which one would be better for observing structure on small angular scales?

3. Suppose you are observing a cluster of sources with the VLA in A configuration at 5 GHz and the widest separation between sources is 5 arcminutes. (a) What is the maximum bandwidth that you can employ so as not to degrade the peak of any source due to bandwidth smearing by more than 5%? (b) What is the maximum integration time allowable for the same limit of 5%? (c) Is the primary beam of the VLA big enough to accommodate this observation? (d) What if you want to observe this same cluster at 43 GHz with similar limits? Hint: consult Tables 8 and 9 of the VLA Status Summary.

4. More on preparing for observing. Lets say that your favorite compact source, 3C84, is in Perseus and you want to reach a sensitivity of 10 microJy/beam (for good polarimetry). (a) What is the RA and Dec (J2000) to a precision of 0.1 arcseconds? (b) What is the galactic latitude and longitude? (c) Use the table in the VLA Status Summary or the exposure calculator to estimate how much time in total you need to ask for if you want to observe with the VLA using 2 GHz bandwidth at 5, 9 and 15 GHz to this noise limit? (d) Add 0.3 hours for absolute flux calibration, what LST (Local Sidereal Time) range do you want to ask for? (e) What local time range does this correspond to on March 1? Note that there are various coordinate calculators (e.g., NED) and I am not asking you to make the various transformations by hand (though you are welcome to do so).

5. You make VLA images of a point source at all 4 stokes and find I=50.0, Q=3, U=-5.2, and V=-0.1 mJy. (a) Calculate the linearly polarized intensity, percentage of linear polarization, and give the polarization angle in degrees. (b) Calculate the percentage of circular polarization. (c) Note that Q, U, and V can be positive or negative. What about stokes I, can that ever be negative?