ASTR240: Radio Astronomy

HW#4

Due April 3, 2013

Problem 1

(Courtesy J. J. Condon & S. M. Ransom)
The spin-down relation in terms of period P is $\dot{P} \propto P^{2-n}$.

A) Use this relation (assuming an initial spin period P_0 to show that the pulsar age T is

$$T = \frac{P}{(n-1)\dot{P}} \left[1 - \left(\frac{P_0}{P} \right)^{n-1} \right] \tag{1}$$

without assuming magnetic dipole braking, constant magnetic field strength, or $P_0 \ll P$.

B) Show that for the common assumptions of $n = 3$ and $P_0 \ll P$ this reduces to the characteristic age, τ_c, as derived in class.

C) If a 100ms pulsar is found with $\tau_c = 30\,\text{kyr}$ in a supernova remnant where historical or kinematic data suggest a true age of only $\sim$2 kyr, what does this imply about the pulsar? Can this discovery constrain the braking index? Why or why not?

Problem 2

(Courtesy M. Faison)

A) What is the fringe spacing θ_f for a two-element, east-west interferometer with a projected baseline of 230 m observing at a frequency of 5 GHz?

B) Two point sources are located in the primary beam of the interferometer 12 arcseconds west of the center and 6 arcseconds east of the center. The west source has a flux that is double that of the east source (call the flux of the east source ”F”). What are the visibility amplitude and phase measured at this instant by the interferometer?

Problem 3

(Adapted from J. Moran)
Early attempts to measure superluminal motions in quasars were based on *very* sparse (u, v) plane data. Whitney et al. (*Science*, 173, 225, 1971; see figure) observed the quasar 3C279 at 4 cm wavelength with a VLBI (Very Long Baseline Interferometer) on October 14, 1970 and February 14, 1971. Their projected baselines were limited to the range of 200-400 cycles per arcsecond. (Note that the natural unit of u and v is cycles per radian.) In October they found a null in the fringe visibility at u = 320 cycles/arcsecond and in February at v = 290 cycles/arcsecond. They fit these data to a model of a double source with changing component separation. The diameters of the antennas are 37 and 64 m, respectively.

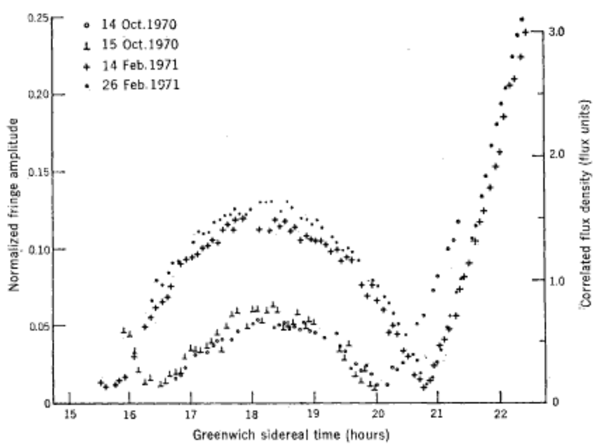

Fig. 1. Fringe-amplitude data from observations of 3C 279 with the Goldstone-Haystack interferometer. Each point is based on 110 seconds of integration.

A) Convince yourself (and me) that the response, V, of the interferometer to a double source with component separation of a and equal brightness temperatures b is

$$|V(u, v)| = 2b\frac{\Omega_s}{\Omega_a}|\cos \pi ua| \tag{2}$$

B) If the peak flux density is 4 Jy (note that 1 Jy used to equal 1 flux unit!), what is the lower limit on the estimate of the brightness temperature of the components if they are unresolved?

C) Show that with this model a varied from 0.00155″ to 0.0017″.

D) Calculate the apparent velocity of separation based on the distance of 2×10^9 pc.

E) As an alternative to this model, show that the data can be explained if in October there was an additional source having a brightness temperature $b'(b' \ll b)$ midway between the other two components that disappeared by February. What might b' have been?