## Radio Astronomy

## Homework 5

Q 5.1 : The full width half power (FWHP) angular size, $\theta$, in radian of the main beam of a diffraction pattern from an aperture of diameter $D$ is $\theta \approx 1.02 \lambda / D$.
(a) Determine the value of $\theta$, in arc min, for the human eye, where $D=0.3 \mathrm{~cm}$, at $\lambda=5 \times 10^{-5} \mathrm{~cm}$.
(b) Repeat for a filled aperture radio telescope, with $D=100 \mathrm{~m}$, at $\lambda=2 \mathrm{~cm}$, and for the Very Large Array (VLA), $D=27 \mathrm{~km}$ at $\lambda=2 \mathrm{~cm}$.

Q 5.2 : Suppose that a Gaussian-shaped source has an actual angular size $\theta_{S}$ and actual peak temperature $T_{0}$. This source is measure with a Gaussian shaped telescope beam size $\theta_{B}$. The resulting peak temperature is $T_{B}$. The flux density $S_{\nu}$, integrated over the entier source, must be a fixed quantity, no matter what the size of the telescope beam.
(a) Use this argument to obtain a relation between temperature integrated over the telescope beam,

$$
T_{B}=T_{0}\left(\frac{\theta_{S}^{2}}{\theta_{B}^{2}+\theta_{S}^{2}}\right)
$$

(b) Show that when the source is small compared to the beam, the main beam brightness temperature $T_{B}=T_{0}\left(\theta_{S} / \theta_{B}\right)^{2}$,
(c) And further the antenna temperature $T_{A}=\eta_{B} T_{0}\left(\theta_{S} / \theta_{B}\right)^{2}$.

Q 5.3 : At a wavelength of 1 cm , assume that the temperature distribution of Jupiter can be expressed as $T_{B}=T_{0}$, and the FWHP source size, is 40 ". If the telescope has a FWHP beam size of 40 ". Assume both the source and beam shapes are Gaussians. Use the results in Q5.2 to calculate the flux density and main beam brightness temperature.

Q5.4 : The 100 m telescope has a geometric collecting area of $7800 \mathrm{~m}^{2}$.
(a) The feed illumination decreases toward the edge of the telescope to reduce the first sidelobe to -24 db below the gain on the axis of the telescope. What is the reduction in for this illumination? (Consult Table 6.1 in "Tools of Radio Astronomy"). (b) The 100 m telescope has feed support legs which are square box-like structures (Consult Figure 6.11 in "Tools of Radio Astronomy"). Model these as four opaque 2 m wide regions. How much is the geometric area reduced in area and in percentage? Actually, the illumination of the 100 m telescope is such that the reduction in collecting area caused by feed support leg blockage is doubled. Now what is the percentage reduction in collecting area caused by feed support leg blockage? Such consideration have led radio astronomers to favor off-axis paraboloids.

