Radio Astronomy Advanced Course II: Report Assignment

Answer the following problems and send you report to takeshi.okuda@nao.ac.jp by email with "Radio Astronomy Report 2019" in the subject line. Its due date is August 9th (Fri), 2019 (JST). The report shall be written in English or Japanese as a PDF file within 10 MB. A scan of your report written by hand is also acceptable. I will send you the acknowledge message within three days after you send it. Please contact me again by email and add takeshi.okuda@alma.cl in CC if you don't receive the acknowledgement message from me. Enjoy!

July 19th, 2019
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1.

A) Suppose that a distribution of brightness temperature of a planet $T_B(\theta,\phi)$ and a normalized beam pattern $P_n(\theta,\phi)$ of a radio telescope are given by,

$$T_B(\theta,\phi) = \begin{cases} T_{B0} & for\ \theta \le \theta_p \\ 0 & for\ \theta > \theta_s \end{cases}$$

$$P_n(\theta,\phi) = \exp\left[-4\ln 2\left(\frac{\theta}{\theta_b}\right)^2\right]$$

where θ_p and θ_b are an angular diameter of the planet and FWHM of a beam, respectively. Obtain an antenna temperature $T_A^*(\theta,\phi)$ and an aperture efficiency η_A when observing the planet.

B) The telescope has a diameter of 10 m and a beam size (θ_b) of 21 arcsec at 350 GHz, and brightness temperature (T_{B0}) and an angular diameter (θ_p) of the planet are 130 K and 6 arcsec, respectively. If T_A^* is 6.0 K, obtain an aperture efficiency and a main beam efficiency of the telescope.

C) If $\eta_A = 0.8\eta_{sf}$ (η_{sf}: surface efficiency), obtain surface accuracy of the telescope.

2.

A) Suppose that you will observe towards one point of an object by CO(J=1-0) by a position switched observation with a single dish telescope (FWHM=20 arcsec). If the system temperature, a frequency bandwidth of a spectrometer, integration time, and quantization levels in the spectrometer are 200 K, 1 MHz, 60 seconds, and 8-levels, estimate achieved ΔT_{rms}. Use an equation for the sensitivity estimation in Lecture 5.

B) The systemic velocity of the object and a rest frequency of CO(J=1-0) are 0 km/s and 115.271 GHz, respectively. Suppose that $X_{\mathrm{CO}} = 3.0 \times 10^{20}$ [cm^{-2} (K km s^{-1})$^{-1}$] in the object and a distance to the object is 5.0 Mpc, obtain 1 σ upper limit of molecular hydrogen mass in the observation when integrating over 200 km/s.