Q4-1

English (Official)

ALMA - Calculating photons (10 points).

ALMA is a radio observatory with a revolutionary design. It consists of 66 high-precision antennas, operating in the wavelength range from $0.32\ mm\ to\ 8.60\ mm$. The principal array has fifty antennas of $12\ m$ diameter each that can work together as a single telescope in the so-called interferometric mode. There is also another array of four $12\ m$ antennas, and twelve smaller antennas of $7\ m$ diameter each.

Imagine that a single $12\ m$ antenna is being calibrated, pointing to a source with a known incident flux of $1 \times 10^{-20}\ W/m^2$

4.1	Assuming that all the flux arrives at the shortest wavelength of ALMA sensitivity, determine the average number of photons that would reach the detector every second.	2.0pt
4.2	Compare it to the average number of photons that would have reached the detector, if all the flux arrived at the longest wavelength of operation.	2.0pt
4.3	What is the angular resolution (in arcsec) of a single $12\ m$ antenna, operating at $74.9\ GHz$?	2.0pt
4.4	Imagine the principal array operating at $74.9\ GHz$ in the interferometric mode. Assuming for simplicity that the spatial resolution is solely given by the longest baseline (largest distance between any pair of antennas), which turns to be $D_{\text{max}} = 16\ km$, what would be the angular resolution (in arcsec) in this case? Treat this case as a single slit aperture instead of a circular one.	2.0pt
4.5	For a radio antenna, the term SEFD refers to 'System Equivalent Flux Density', which is a characteristic energy flux density of the antenna, depending on its temperature and size. We also note that for energy estimation of radio photons, Rayleigh-Jeans approximation is valid. Assuming a system temperature of $691\ K$, what would be the SEFD of the full ALMA observatory in Jansky if all the 66 antennas could work together?	2.0pt