ASTRONOMY 4010 ASSIGNMENT
DUE: 11 April 2008

Prof. Paul Wiita

I am giving my first presentation on Radio Telescopes today, and won't give the second on Radio Astronomy until 25 April. Dr. Crenshaw will meet you the intervening two Fridays and my assignment is to be handed in to him next Friday or, if necessary, left in an envelope in my mailbox no later than 9:30 AM on Monday, April 14th.

One hundred radio telescopes, each of an effective area of 150 m², operating continuously over the past 20 years, is a reasonable estimate of the total radio observing capabiltities of our species. Assume that each of these telescopes operates at 1 GHz with a bandwidth of 10 MHz (most actually do have a band pretty close to 1 GHz, and bandwidths of 5–50 MHz are common). Assume that the typical source they have been observing is an extragalactic radio source of total power $L_{\mathrm{R}} = 10^{43}$erg s^{-1}, and each has a spectral index, $\alpha = -0.75$ (defined so that $P_\nu \propto \nu^{+\alpha}$), with abrupt spectral cutoffs below 10 MHz and above 100 GHz. (This range is the usual "radio band".)

Further, take these radio sources to have a typical redshift, z, of 0.15. Take the Hubble constant to be $H_0 = 75$ km s^{-1}Mpc^{-1}. Recall that $cz \simeq H_0 d$, that 1 pc $= 3.085678 \times 10^{18}$cm, and that the heat capacity of water is 1.0 cal g^{-1}K^{-1}, where 1 cal $= 4.18 \times 10^7$ erg.

Compute, showing your work:

(a) The specific power at one GHz, $\mathrm{P}_\nu(\nu = 10^9\mathrm{Hz})$, in units of erg s^{-1}Hz^{-1}, emitted by such a typical source.

(b) The distance, d, to the typical source.

(c) The flux (density), $\mathrm{F}_\nu(\nu = 10^9\mathrm{Hz})$ in both erg s^{-1}cm^{-2}Hz^{-1} and in Janskys arriving at the earth.

(d) The power absorbed by one typical radio telescope operating as defined above from this typical source.

(e) The antenna temperature while observing this source.

(f) The amount of water that would be raised 1°K in temperature if all the radio energy collected by *all* of these radio telescopes, each operating as defined above, over *all* the abovementioned time were to be applied to heating it.

HINTS: The only really difficult part is (a); if you can't derive the answer, here it is, for use in parts (c) and onwards: 8.78×10^{32}erg s^{-1}Hz^{-1}. In parts (d)–(f) do not neglect the bandwidth!