Radboud Universiteit Nijmegen
Afdeling Sterrenkunde
Jörg R. Hörandel

Radioastronomie – 2008/09

Werkcollege 2 – 19.02.2009

1. What is the temperature equivalent of the energy E for 1 electron volt, i.e. 1 eV? Set $E = kT$. If this energy is contained in one photon, what is the wavelength of this photon? What is the frequency in units of Hz? Another commonly used equivalent energy unit is cm^{-1}. What is the value for 1 eV in cm^{-1}? Repeat all steps for 3 K, 10 K, and 144 K.

2. A unit commonly used in astronomy is flux density S_ν. The usual unit for S_ν is the Jansky (Jy). Calculate the flux density in Jy of a small angular size microwave source with an output of 600 W at a distance of 10 m if the power is isotropically radiated and is uniformly emitted over a bandwidth of 10^6 Hz.

3. Suppose the extraterrestrials in the next planetary system, assumed to be at a distance of 1 pc, use a 200 MW transmitter to broadcast information at a wavelength of 21 cm over a bandwidth B of 10 kHz. The emission is assumed to be uniform over this band. What would be the flux density we receive in Jy? How many Watts would be collected with an antenna with an area $A = 7800\ \mathrm{m}^2$?

4. Reformulate the Planck relation

$$B_\nu(T) = \frac{2h\nu^3}{c^2}\frac{1}{\exp(h\nu/kT) - 1}$$

in terms of λ and T and then determine the dependence of the peak intensity on λ and on T.

Hints: use $B_\nu(T)\mathrm{d}\nu = -B_\lambda(T)\mathrm{d}\lambda$ and $d\nu = -c/\lambda^2\mathrm{d}\lambda$. To derive the λ-dependent Wien displacement law you need to set $\partial B_\lambda/\partial\lambda = 0$. Use the substitution $x = hc/k\lambda T$. Give $B_{\lambda,max}$ as function of T and λ.