Introduction to Astronomy
Exercises week 15

31 January 2020

1. One definition of the habitable zone, is that region of space around a star, where the average temperature of a planetary body would be between 0°C and 100°C.
   (a) Calculate the habitable zone for the Solar System. To do so, equate the incoming flux from the Sun with the outgoing flux from the planet's black-body radiation (use the Stefan-Boltzmann law for this). In considering the incident solar radiation, assume an albedo (i.e. the fraction of incident light that is directly reflected) of 0.31, as for the Earth.
   (b) Same question, but now for an Earth-like planet orbiting Aldebaran, which has a temperature of 3910 K and a radius of $55.2\,\mathrm{R}_\odot$.
2. If there are N stars in a volume V, a fraction q of which are habitable, estimate the average distance between two habitable planets. (Hint: this is a trivial question: base it on the average volume per star.) Apply your solution to the Solar neighbourhood, where we have roughly 47 star (systems) within $520\,\mathrm{pc}^3$. Assume 1% and respectively 0.001% of these stars have habitable planets.
3. (Off-topic question:) As you know, flux (expressed in W/m^2) is luminosity (in W) per area. In radio astronomy, typically the unit of flux *density* is used instead, adding in the bandwidth of the radiation. In SI units, flux density would be expressed in $W/m^2/Hz$, but for any practical purpose, the *Jansky* is used, defined as: $1\,\mathrm{Jy} = 10^{-26}\,\mathrm{W/m^2/Hz}$, because most typical radio astronomy sources have fluxes of the order 1 Jy to 1 mJy. Now consider a microwave oven with a power of 1 kW, placed on the moon. Suppose its power is emitted across a bandwidth of 100 MHz, centred at 2.7 GHz. Calculate the flux density of this microwave oven, on Earth. Would this object be visible with a radio telescope?