BOLOMETRIC MAGNITUDE FROM FLUX

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Reference: Carroll, Bradley W. & Ostlie, Dale A. (2007), *An Introduction to Modern Astrophysics*, 2nd Edition; Pearson Education - Chapter 3, Problem 3.17.

The apparent magnitude of a star at a particular wavelength can be written in terms of the flux observed at that wavelength on Earth by

$$m = -2.5\log\int F_\lambda S_\lambda d\lambda + C \tag{1}$$

$$C \equiv M_{Sun} + 2.5\log\int F_{\lambda,10,Sun} S_\lambda d\lambda \tag{2}$$

Here S_λ is the sensitivity function and indicates what fraction of the actual flux a particular telescope receives at a given wavelength. This formula is actually not well-formed since whenever we use a transcendental function such as the logarithm, its argument should be dimensionless. It is true that if we combine the two terms into a single logarithm, we get

$$m = -2.5\log\frac{\int F_\lambda S_\lambda d\lambda}{\int F_{\lambda,10,Sun} S_\lambda d\lambda} + M_{Sun} \tag{3}$$

giving a dimensionless argument for the log term. However, in the original form, the constant C depends on the units used for the flux.

It seems to be standard to use watts m^{-2} for total flux, so the units of F_λ are watts $\mathrm{m}^{-2}\ \mathrm{nm}^{-1}$ if the wavelength λ is given in nanometres.

For a bolometric magnitude, we set $S_\lambda = 1$ for all λ. The bolometric flux for the Sun at the distance of Earth is

$$\int_0^\infty F_\lambda d\lambda = 1365\ \mathrm{W\ m}^{-2} \tag{4}$$

Taking the apparent bolometric magnitude of the Sun as $m_{Sun} = -26.83$ we get

$$C_{bol} = -18.992 \tag{5}$$

As a consistency check, we can plug in the values for Dschubba (Delta Sco), whose flux at Earth is $F = 6.44\times10^{-8}\ \mathrm{W\ m}^{-2}$:

$$m = -2.5\log\left(6.44\times 10^{-8}\right) - 18.992 = -1.01 \tag{6}$$

which just gives us the bolometric magnitude we had before.