

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

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

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

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

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

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 $\text{m}^{-2} \text{nm}^{-1}$ 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

$$(4) \quad \int_0^{\infty} F_{\lambda} d\lambda = 1365 \text{ W m}^{-2}$$

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

$$(5) \quad C_{bol} = -18.992$$

As a consistency check, we can plug in the values for Dschubba (Delta Sco), whose flux at Earth is $F = 6.44 \times 10^{-8} \text{ W m}^{-2}$:

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

which just gives us the bolometric magnitude we had before.