Research Note on Optical/NIR and MIR Fluxes

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Abstract

I've been keen to have a "cheat sheet" for some time on just the raw measurement of flux from optical (read SDSS), near-infrared (read UKIDSS and VISTA) and the mid-infrared (read *Spitzer* and WISE).

1 Useful Resources

http://idlastro.gsfc.nasa.gov/ftp/pro/astro/flux2mag.pro

2 AB magnitudes

It is based on flux measurements that are calibrated in absolute units, namely spectral flux densities. The monochromatic AB magnitude is defined as the logarithm of a spectral flux density with the usual scaling of astronomical magnitudes and a zero-point of 3631 Jansky (Oke, 1983) where

$$\begin{aligned} 1\text{Jansky} &= 10^{-26}\ \text{W Hz}^{-1}\ \text{m}^{2} && (1)\\ &= 10^{-23}\ \text{erg s}^{-1}\ \text{Hz}^{-1}\ \text{cm}^{-2}. && (2)\\ & && (3) \end{aligned}$$

If the spectral flux density is denoted f_ν, the monochromatic AB magnitude is:

$$\begin{aligned} m_{\text{AB}} &= -2.5\log_{10}\left(\frac{f_\nu}{3631\ \text{Jy}}\right) && (4)\\ &= -2.5\log_{10} f + 8.9 \text{ (magnitude m and flux in Jy)} && (5)\\ &= -2.5\log_{10} f + 16.4 \text{ (magnitude m and flux in mJy)} && (6)\\ &= -2.5\log_{10} f + 23.9 \text{ (magnitude m and flux in } \mu\text{Jy)} && (7)\\ &= -2.5\log_{10} f - 48.6 \text{ (flux in erg s}^{-1}\text{ cm}^{-2}\text{Hz}^{-1}) && (8)\\ &= -2.5\log_{10} f - 56.1 \text{ (flux in W Hz}^{-1}\text{ m}^{-2}) && (9) \end{aligned}$$

since $\log_{10}(3631^{-23}) \times 2.5 = -48.5999$) and factor of $\log_{10}(10^3) \times 2.5$ for the last lines. In the AB system, the flux zero-point in every filter is *defined* to be 3631 Jy (Janskys; 1 Jy = 10^{-26} W Hz^{-1} m^{-2}).

3 Optical/SDSS fluxes

Straight from: http://www.sdss3.org/dr8/algorithms/magnitudes.php.

In SDSS-III, we express all fluxes in terms of nanomaggies, which are a convenient linear unit. For example, quantities labeled petroFlux, psfFlux, etc. are (unless otherwise stated) in these units. In each case, there is a corresponding asinh magnitude, such as petroMag, psfMag etc., explained further below.

A "maggy" is the flux f of the source relative to the standard source f_0 (which defines the zeropoint of the magnitude scale). Therefore, a "nanomaggy" is 10^{-9} times a maggy. These fluxes are in a unit of nanomaggies, a system where the zero-point flux is (3631×10^9) Jy or 10^9 f_0. To relate these quantities to standard magnitudes, an object with flux f given in nMgy has a Pogson magnitude:

$$
\begin{aligned}
m_{\mathrm{SDSS}} &= -2.5\ \log_{10}(f/10^9 f_0) && (10)\\
&= -2.5\ \log 10(f/f_0) + 2.5\log_{10}(10^9) && (11)\\
&= 22.5 - 2.5\log 10(f/f0) && (12)\\
& && (13)
\end{aligned}
$$

Note that magnitudes listed in the SDSS catalog, however, are not standard Pogson magnitudes, but asinh magnitudes.

The standard source for each SDSS band is close to but not exactly the AB source (3631 Jy), **meaning that a nanomaggy is approximately 3.631×10^{-6} Jy**. However, our current understanding is that the absolute calibration of the SDSS system has some percent-level offsets relative to AB, discussed in detail in the section on AB calibration.

So, in the SDSS datasweep files, to convert the FLUX tags to magnitudes, simply take: $m = 22.5 - 2.5\ log_{10}(\mathrm{FLUX})$.

4 Near Infrared fluxes

Double check with Coleman

5 Mid-Infrared fluxes

5.1 Spitzer

From Ashby et al. (2013, SSDF paper...)
zero_pt_Ch1 = 18.789
zero_pt_Ch2 = 18.316

Band	$F_{\nu\,0}$[Jy]	$F^*_{\nu\,0}$[Jy]
W1	309.540	306.682
W2	171.787	170.663
W3	31.674	29.045
W4	8.363	8.284

Table 1: Zero Magnitude Flux Density

Ch1 = zero_pt_Ch1 - 2.5*alog10(flux_ch1)
Ch2 = zero_pt_Ch2 - 2.5*alog10(flux_ch2)

5.2 WISE

Straight from: wise2.ipac.caltech.edu/docs/release/allsky/expsup/sec4_4h.html
The source flux density, in Jansky [Jy] units, is computed from the calibrated WISE magnitudes, mvega using:

$$F_\nu[\mathrm{Jy}] = F_{\nu\,0} \times 10^{(-m_{\mathrm{Vega}}/2.5)} \tag{14}$$

where is the zero magnitude flux density corresponding to the constant that gives the same response as that of Alpha Lyrae (Vega). For most sources, the zero magnitude flux density, derived using a constant power-law spectra, is appropriate and may be used to convert WISE magnitudes to flux density [Jy] units. Table 1 lists the zero magnitude flux density (column 2) for each WISE band.

For sources with steeply rising MIR spectra or with spectra that deviate significantly from F=constant, including cool asteroids and dusty star-forming galaxies, a color correction is required, especially for W3 due to its wide bandpass. With a given flux correction, fc, the flux density conversion is given by:

$$F_\nu[\mathrm{Jy}] = (F^*_{\nu\,0}/f_c) \times 10^{(-m_{\mathrm{Vega}}/2.5)} \tag{15}$$

where is the zero magnitude flux density derived for sources with power-law spectra: $F_\nu \propto \nu^{-2}$ listed in Table 5.2 (column 3) and the flux correction, f_c, listed in Wright et al. (2010; their Table 1) for , where the index α ranges from: -3, -2, -1, 0, 1, 2, 3, and 4, and for blackbody spectra, B_ν(T) for a variety of temperatures, and for stars of two main-sequence spectral types (K2V and G2V).

References

Oke, J. B.; Gunn, J. E. 1983ApJ...266..713O