Astronomical Magnitude Systems

Contents:

Definitions of astronomical magnitude systems:

Johnson System

This system is defined such that the star Alpha Lyr (Vega) has V=0.03 and all colors equal to zero. Alternatively, the zero-color standard can be defined to be the mean of a number of unreddened A0 V stars of Pop I abundance, using the ensemble of Johnson-Morgan standards to fix the flux scale. It remains to calibrate on an absolute scale the flux of Alpha Lyr or some other appropriate star, Such as aclaibration has been accomplished by Hayes and Lathan (1975), which yielded 3500 Jansky at 5556A for Alpha Lyr. Articles discussing the UBVRI passbands include Bessel (1979), Bessel (1983), and Bessel (1990).

References:

- Bessel, M. S. 1990, PASP, 91, 589
- Bessel, M. S. 1983, PASP, 95, 480
- Bessel, M. S. 1990, PASP, 102, 1181
- Hayes, D. S., & Latham, D. W. 1975, ApJ, 197, 593
- Johnson, H. L. & Morgan, W. W. 1953, ApJ, 117, 313

Gunn griz System

This was originally defined in terms of photoelectric detectors (Thuan & Gunn 1976; Wade et al. 1979), but is now used primarily with CCDs (Schneider, Gunn, & Hoessel 1983; Schild 1984). The griz system is defined by a few dozen standard stars, and the star BD+17deg4708, a subdwarf F6 star with B-V=0.43, is defined to have colors equal to zero. The absolute calibration of this system is simply the monochromatic flux of the star (Oke & Gunn 1983), scaled from g=9.50 to g=0.0, at the effective wavelengths of the griz bands. A number of detailed aspects of broad-band photometry in the specific context of measurements of galaxies at large redshifts are reviewed in Schneider, Gunn, & Hoessel (1983).

References:

- Oke, J. B., & Gunn, J. E. 1983, ApJ, 266, 713
- Schild, R. 1984, ApJ, 286, 450
- Schneider, D. P., Gunn, J. E., & Hoessel J. G. 1983, ApJ, 264, 337
- Thuan, T. X., & Gunn, J. E. 1976, PASP, 88, 543
- Wade, R. A., Hoessel, J. G., Elias, J. H., Huchra, J. P. 1979, PASP, 91, 35

AB magnitude System

This magnitude system is defined such that, when monochromatic flux f is measured in erg sec^-1 cm^-2 Hz^-1,

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m(AB) = -2.5 log(f) - 48.60
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where the value of the constant is selected to define m(AB)=V for a flat-spectrum source. In this system, an object with constant flux per unit *frequency* interval has zero color.

References:

- Oke, J.B. 1974, ApJS, 27, 21

STMAG system

This magnitude system is defined such that an object with constant flux per unit *wavelength* interval has zero color. It is used by the Hubble Space Telescope photometry packages.

References:

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Conversions among magnitude systems:

Conversion from AB magnitudes to Johnson magnitudes:

The following formulae convert between the AB magnitude systems and those based on Alpha Lyra:

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    V  =   V(AB) + 0.044       (+/- 0.004)
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  B  =   B(AB) + 0.163       (+/- 0.004)
 Bj  =  Bj(AB) + 0.139       (+/- INDEF)
  R  =   R(AB) - 0.055       (+/- INDEF)
  I  =   I(AB) - 0.309       (+/- INDEF)
  g  =   g(AB) + 0.013       (+/- 0.002)
  r  =   r(AB) + 0.226       (+/- 0.003)
  i  =   i(AB) + 0.296       (+/- 0.005)
  u' =  u'(AB) + 0.0
  g' =  g'(AB) + 0.0
  r' =  r'(AB) + 0.0
  i' =  i'(AB) + 0.0
  z' =  z'(AB) + 0.0
 Rc  =  Rc(AB) - 0.117       (+/- 0.006)
 Ic  =  Ic(AB) - 0.342       (+/- 0.008)
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Source: Frei & Gunn 1995

Conversion from STMAG magnitudes to Johnson magnitudes:
See the WFPC2 Photometry Cookbook

Photon Flux:

Given the passband and the magnitude of an object, the number of tphotons incident at the top of the atmosphere may be estimated using the data in this table:

Band	lambda_c	dlambda/lambda	Flux at m=0	Reference
	um		Jy	
U	0.36	0.15	1810	Bessel (1979)
B	0.44	0.22	4260	Bessel (1979)
V	0.55	0.16	3640	Bessel (1979)
R	0.64	0.23	3080	Bessel (1979)
I	0.79	0.19	2550	Bessel (1979)
J	1.26	0.16	1600	Campins, Reike, & Lebovsky (1985)
H	1.60	0.23	1080	Campins, Reike, & Lebovsky (1985)
K	2.22	0.23	670	Campins, Reike, & Lebovsky (1985)

g	0.52	0.14	3730	Schneider, Gunn, & Hoessel (1983)
r	0.67	0.14	4490	Schneider, Gunn, & Hoessel (1983)
i	0.79	0.16	4760	Schneider, Gunn, & Hoessel (1983)
z	0.91	0.13	4810	Schneider, Gunn, & Hoessel (1983)

Also useful are these identities:

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1 Jy = 10^-23 erg sec^-1 cm^-2 Hz^-1
1 Jy = 1.51e7 photons sec^-1 m^-2 (dlambda/lambda)^-1
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Example: How many V-band photons are incident per second on an area of 1 m^2 at the top of the atmosphere from a V=23.90 star? From the table, the flux at V=0 is 3640 Jy; hence, at V=23.90 the flux is diminished by a factor 10^(-0.4*V)=2.75e-10, yielding a flux of 1.e-6 Jy. Since dlambda/lambda=0.16 in V, the flux per second on a 1 m^2 aperture is

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f=1.e-6 Jy * 1.51e7 * 0.16 = 2.42 photons sec^-1
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Filter Transformations:

All filter transformations depend to some extent on the spectral type of the object in question. If this is known, then you are probably best off using the SYNPHOT package in IRAF/STSDAS to compute the transformation. Some transformations are listed below for convenience:

Bands	Equation	Reference
Gunn g to Johnson B:	B = g + 0.51 + 0.60*(g-r)	[1]
Gunn g to Johnson V:	V = g - 0.03 - 0.42*(g-r)	[1]
Gunn r to Mould R:	R = r - 0.51 - 0.15*(g-r)	[1]
Gunn g to Photographic J:	J = g + 0.39 + 0.37*(g-r)	[1]
Gunn r to Photographic F:	F = r - 0.25 + 0.17*(g-r)	[1]
Gunn i to Mould I:	I = i - 0.75 (approx)	[1]

References:

1. Windhorst, R. W., et al. 1991, ApJ, 380, 362

Night Sky Brightnesses:

These values are appropriate for taken from CTIO but should serve as reasonable approximations for most dark sites:

Lunar Age (days)	U	B	V	R	I
0	22.0	22.7	21.8	20.9	19.9
3	21.5	22.4	21.7	20.8	19.9
7	19.9	21.6	21.4	20.6	19.7
10	18.5	20.7	20.7	20.3	19.5
14	17.0	19.5	20.0	19.9	19.2

Source: NOAO Newsletter #10.

Notice: This material is adapted from the appendix to the unpublished manuscript *Observations of Distant Galaxies* by R. Kron and H. Spinrad, without permission of the authors.

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