Flux Units and NICMOS

C. J. Skinner
February 23, 1996

ABSTRACT

In the infrared, as in the optical, the means of reporting source brightnesses and the units employed have varied considerably. In recent years, however, 'magnitude' systems have been used less frequently, and the most popular unit for expressing brightnesses, both for point source fluxes and surface brightnesses, is steadily becoming the Jansky. We propose to adopt the Jansky as the standard flux unit for NICMOS in our documentation and in observer-oriented software, and we provide here some simple formulae and tables to facilitate the conversion from other units into Jy.

1. A Little History

IR astronomy really began in the 1960's, when the vast majority of astronomy was still carried out in the visual region. Flux measurements were routinely reported in the UBV magnitude system, and to attempt to integrate IR astronomy into this system, Johnson (Ap.J., **134**, 69) defined the first IR magnitude system. This involved four new photometric bands, the J, K, L and M bands which were centered on wavelengths of 1.3, 2.2, 3.6 and 5.0µm. These bands were defined not only by the filter bandpasses, but also by the wavebands of the 'windows' of high transmission through the atmosphere. In this system, all measurements were referred to the Sun, which was assumed to be a G2V star with an effective temperature of 5785K, and was taken to have a V-K colour of roughly +2.2. From his own measurements in this system, Johnson determined Vega to have a K magnitude of +0.02 and K-L=+0.04.

Until the early 1980's IR astronomical observations were restricted to spectra or single channel photometry, and most photometry was reported in systems at least loosely based on Johnson's system, though with the addition of a new band at 1.6µm known as the H band and the development of two bands in place of the one formerly defined by Johnson as the L band, a new definition of the L band centered on 3.4µm, and a rather narrower band known as L' centered on 3.74µm.

As the new science of infrared astronomy rapidly expanded its wavelength coverage, many new photometric bands were adopted, both for ground-based observations and for use by the many balloon- and rocket-borne observations and surveys. The differing constraints presented by these different environments for IR telescopes resulted in systems with disappointingly little commonality or overlap, and today the IR astronomer is left with a plethora of different systems to work with.

The IRAS survey results, which were published in 1986, presented observations made photometrically in four bands in the mid- and far-infrared, and mid-infrared spectra, and all were presented in units of Janskys, rather than defining yet another new magnitude system. Since then, IR data from many sites around the world have been increasingly commonly presented in Jy, or in Jy/arcsec^2 in the case of surface brightness data (although IRAS maps are often presented in the rather grandiloquent units of MJy/steradian).

Ground-based mid-IR photometry is usually carried out using the N and Q photometric bands, which are themselves defined more by the atmospheric transmission than by any purely scientific regard. IRAS, freed of the constraints imposed by the atmosphere, adopted its own 12μm and 25μm bands, which were extremely broad and therefore offered high sensitivity. Similarly, NICMOS, being above the atmosphere, is not forced to adopt filter bandpasses like those used at ground-based observatories, but instead has filters constrained purely by the anticipated scientific demands. Thus in practise NICMOS does not have filters matched to any of the standard ground-based photometric bands.

2. Units for NICMOS

In order to facilitate proposal preparation by GTOs and GOs, STScI is making available a number of computer programs to assist with Signal/Noise Ratio (SNR) and integration time calculations. We are also presenting a great deal of sensitivity information in the NICMOS Handbook. Given the multitude of units and systems that have been used for IR photometry (magnitudes, Jy, $Wm^{-2}\mu m^{-1}$, $Wcm^{-2}\mu m^{-1}$, erg $sec^{-1}cm^{-2}\mu m^{-1}$) and for surface brightness measurements (Jy $arcsec^{-2,}$ MJy $steradian^{-1}$, magnitudes $arcsec^{-2}$), presenting these data to observers could become somewhat cumbersome. Additionally, given the lack of any 'standard' IR filters (as explained above), in order to express brightnesses in magnitudes we would have to adopt our own NICMOS magnitude system, and GOs would have to transform ground-based photometry into the NICMOS bands. We are therefore proposing instead to adopt a single standard set of flux units to be used in all NICMOS documentation and observer-oriented software. These will be the Jy for all photometry and spectroscopy, and the Jy $arcsec^{-2}$ for all surface brightness measurements.

We are aware that some observers do not routinely use these units, and therefore we will supply software to perform conversions between different systems and units. We are also supplying, in this ISR, a set of simple formulae to use to convert between systems, and some conversion tables. The NICMOS calibration pipeline software will be set up to deliver results calibrated in Jy $arcsec^2$.

3. Formulae

Conversion between F_ν and F_λ

1Jy is defined as $10^{-26} Wm^{-2} Hz^{-1}$, so it is a unit of measurement of the spectral flux density, F_ν.

For F_ν in Jy, use the following formula:

$F_\lambda = \beta F_\nu / \lambda^2$, where λ is the wavelength in microns (μm), and β is a constant chosen from Table 1 and depending on the units of F_λ. (This is simply derived, using the fact that $d\nu/d\lambda = c/\lambda^2$.)

Table 1: constants for conversion between F_λ and F_ν

F_λ measured in	β
$Wm^{-2}\mu m^{-1}$	$3x10^{-12}$
$Wcm^{-2}\mu m^{-1}$	$3x10^{-16}$
erg sec^{-1} cm^{-2} μm^{-1}	$3x10^{-9}$
erg sec^{-1} cm^{-2} $Å^{-1}$	$3x10^{-13}$

(Remember that $1W=10^7 erg$, and $1\mu m=10^4 Å$.)

Conversion between fluxes and magnitudes

The spectral flux density F_ν can be calculated from its magnitude as

$$F_\nu = 10^{-m/2.5} F_o$$

where m is the magnitude and F_o the zero-point flux for the given photometric band. We list the central wavelengths and zero-point fluxes for the more commonly encountered photometric bands below in Table 2. The CIT system was originally based on Beckwith et al (1976, Ap.J., **208**, 390); the UKIRT system is in fact based on the original CIT system, but with adjustments made largely owing to different filter bandpasses. It should be noted that for a given photometric band there will be small differences in the effective wavelength and zero-point flux from one observatory to another, and for astronomical objects with radically different colours, so these figures can only be treated as approximate.

Table 2: effective wavelengths and zero-points for photometric bands

Band	λ[μm]	F_o[Jy] (CIT)	F_o[Jy] (UKIRT)
V	0.56	3540	3540
R	0.70	2870	-
I	0.90	2250	-
J	1.25	1670	1600
H	1.65	980	1020
K	2.2	620	657
L	3.4	280	290
L'	3.74	-	252
M	4.8	150	163
N	10.1	37	39.8
Q	20.0	10	10.4

Conversion between surface brightness units

Surface brightnesses are generally measured in Jy arcsec^{-2}, MJy steradian^{-1} or magnitudes arcsec^{-2}. If you have a surface brightness S_ν in Mjy steradian^{-1}, then you can use

S_ν[Jy arcsec^{-2}] = S_ν[MJy ster^{-1}]x0.084616.

If you have S_ν in magnitudes arcsec^{-2}, you can simply use the formula and zero-points as given in the previous section for point sources.

4. Look-up Tables and Software

In this section we provide look-up tables to facilitate rapid, approximate conversion between the different systems mentioned in the preceding section.

For both integrated source fluxes and surface brightnesses, we provide tables of conversions between systems at the wavelengths of the four commonly used photometric bands which cover the NICMOS operating waveband of 0.8-2.5μm. To carry out some of the conversions described here, some simple Fortran programs will shortly be available on the NICMOS World-Wide Web pages at STScI. We are adopting here the CIT system defined in Table 2.

Table 3: F_ν to magnitude conversion table

F_ν [Jy]	I	J	H	K
10.0	5.88	5.56	4.98	4.48
8.0	6.12	5.80	5.22	4.72
6.0	6.44	6.11	5.53	5.04
5.0	6.63	6.31	5.73	5.23
4.0	6.88	6.55	5.97	5.48
3.0	7.19	6.86	6.29	5.79
2.5	7.39	7.06	6.48	5.99
2.0	7.63	7.30	6.73	6.23
1..5	7.94	7.62	7.04	6.54
1.25	8.14	7.81	7.24	6.74
1.0	8.38	8.06	7.48	6.98
0.8	8.62	8.30	7.72	7.22
0.6	8.94	8.61	8.03	7.54
0.5	9.13	8.81	8.23	7.73
0.4	9.38	9.05	8.47	7.98
0.3	9.69	9.36	8.79	8.29
0.25	9.89	9.57	8.98	8.49
0.2	10.13	9.8	9.23	8.73
0.15	10.44	10.12	9.54	9.04
0.125	10.64	10.31	9.74	9.24
0.1	10.88	10.56	9.98	9.48

By using this table it is possible to estimate the CIT magnitude corresponding to any flux in Jy, by using the property that multiplying or dividing the flux by one hundred adds or subtracts five magnitudes.

Table 4: I-band flux conversion table

F_ν [Jy]	I [mag]	F_λ [Wm^{-2}μm^{-1}]	F_λ [Wcm^{-2}μm^{-1}]	F_λ [erg s^{-1} cm^{-2} Å^{-1}]
2250	0.0	8.32×10^{-9}	8.32×10^{-13}	8.32×10^{-10}
894	1.0	3.312×10^{-9}	3.312×10^{-13}	3.312×10^{-10}
356	2.0	1.319×10^{-9}	1.319×10^{-13}	1.319×10^{-10}
142	3.0	5.25×10^{-10}	5.25×10^{-14}	5.25×10^{-11}
56.4	4.0	2.09×10^{-10}	2.09×10^{-14}	2.09×10^{-11}
22.5	5.0	8.32×10^{-11}	8.32×10^{-15}	8.32×10^{-12}
8.94	6.0	3.312×10^{-11}	3.312×10^{-15}	3.312×10^{-12}
3.56	7.0	1.319×10^{-11}	1.319×10^{-15}	1.319×10^{-12}
1.42	8.0	5.25×10^{-12}	5.25×10^{-16}	5.25×10^{-13}
0.564	9.0	2.09×10^{-12}	2.09×10^{-16}	2.09×10^{-13}
0.225	10.0	8.32×10^{-13}	8.32×10^{-17}	8.32×10^{-14}
0.0894	11.0	3.312×10^{-13}	3.312×10^{-17}	3.312×10^{-14}
0.0356	12.0	1.319×10^{-13}	1.319×10^{-17}	1.319×10^{-14}
0.0142	13.0	5.25×10^{-14}	5.25×10^{-18}	5.25×10^{-15}
0.00564	14.0	2.09×10^{-14}	2.09×10^{-18}	2.09×10^{-15}
0.00225	15.0	8.32×10^{-15}	8.32×10^{-19}	8.32×10^{-16}
8.94×10^{-4}	16.0	3.312×10^{-15}	3.312×10^{-19}	3.312×10^{-16}
3.56×10^{-4}	17.0	1.319×10^{-15}	1.319×10^{-19}	1.319×10^{-16}
1.42×10^{-4}	18.0	5.25×10^{-16}	5.25×10^{-20}	5.25×10^{-17}
5.64×10^{-5}	19.0	2.09×10^{-16}	2.09×10^{-20}	2.09×10^{-17}
2.25×10^{-5}	20.0	8.32×10^{-17}	8.32×10^{-21}	8.32×10^{-18}
8.94×10^{-6}	21.0	3.312×10^{-17}	3.312×10^{-21}	3.312×10^{-18}
3.56×10^{-6}	22.0	1.319×10^{-17}	1.319×10^{-21}	1.319×10^{-18}
1.42×10^{-6}	23.0	5.25×10^{-18}	5.25×10^{-22}	5.25×10^{-19}
5.64×10^{-7}	24.0	2.09×10^{-18}	2.09×10^{-22}	2.09×10^{-19}
2.25×10^{-7}	25.0	8.32×10^{-19}	8.32×10^{-23}	8.32×10^{-20}
8.94×10^{-8}	26.0	3.312×10^{-19}	3.312×10^{-23}	3.312×10^{-20}

Table 5: J-band flux conversion table

F_ν [Jy]	J [mag]	F_λ [$Wm^{-2}\mu m^{-1}$]	F_λ [$Wcm^{-2}\mu m^{-1}$]	F_λ [$erg\ cm^{-2}s^{-1}Å^{-1}$]
1670	0.0	$3.21 x 10^{-9}$	$3.21 x 10^{-13}$	$3.21 x 10^{-10}$
665	1.0	$1.28 x 10^{-9}$	$1.28 x 10^{-13}$	$1.28 x 10^{-10}$
265	2.0	$5.08 x 10^{-10}$	$5.08 x 10^{-14}$	$5.08 x 10^{-11}$
106	3.0	$2.02 x 10^{-10}$	$2.02 x 10^{-14}$	$2.02 x 10^{-11}$
42.0	4.0	$8.06 x 10^{-11}$	$8.06 x 10^{-15}$	$8.06 x 10^{-12}$
16.7	5.0	$3.21 x 10^{-11}$	$3.21 x 10^{-15}$	$3.21 x 10^{-12}$
6.65	6.0	$1.28 x 10^{-11}$	$1.28 x 10^{-15}$	$1.28 x 10^{-12}$
2.65	7.0	$5.08 x 10^{-12}$	$5.08 x 10^{-16}$	$5.08 x 10^{-13}$
1.06	8.0	$2.02 x 10^{-12}$	$2.02 x 10^{-16}$	$2.02 x 10^{-13}$
0.420	9.0	$8.06 x 10^{-13}$	$8.06 x 10^{-17}$	$8.06 x 10^{-14}$
0.167	10.0	$3.21 x 10^{-13}$	$3.21 x 10^{-17}$	$3.21 x 10^{-14}$
0.0665	11.0	$1.28 x 10^{-13}$	$1.28 x 10^{-17}$	$1.28 x 10^{-14}$
0.0265	12.0	$5.08 x 10^{-14}$	$5.08 x 10^{-18}$	$5.08 x 10^{-15}$
0.0106	13.0	$2.02 x 10^{-14}$	$2.02 x 10^{-18}$	$2.02 x 10^{-15}$
0.00420	14.0	$8.06 x 10^{-15}$	$8.06 x 10^{-19}$	$8.06 x 10^{-16}$
0.00167	15.0	$3.21 x 10^{-15}$	$3.21 x 10^{-19}$	$3.21 x 10^{-16}$
$6.65 x 10^{-4}$	16.0	$1.28 x 10^{-15}$	$1.28 x 10^{-19}$	$1.28 x 10^{-16}$
$2.65 x 10^{-4}$	17.0	$5.08 x 10^{-16}$	$5.08 x 10^{-20}$	$5.08 x 10^{-17}$
$1.06 x 10^{-4}$	18.0	$2.02 x 10^{-16}$	$2.02 x 10^{-20}$	$2.02 x 10^{-17}$
$4.20 x 10^{-5}$	19.0	$8.06 x 10^{-17}$	$8.06 x 10^{-21}$	$8.06 x 10^{-18}$
$1.67 x 10^{-5}$	20.0	$3.21 x 10^{-17}$	$3.21 x 10^{-21}$	$3.21 x 10^{-18}$
$6.65 x 10^{-6}$	21.0	$1.28 x 10^{-17}$	$1.28 x 10^{-21}$	$1.28 x 10^{-18}$
$2.65 x 10^{-6}$	22.0	$5.08 x 10^{-18}$	$5.08 x 10^{-22}$	$5.08 x 10^{-19}$
$1.06 x 10^{-6}$	23.0	$2.02 x 10^{-18}$	$2.02 x 10^{-22}$	$2.02 x 10^{-19}$
$4.20 x 10^{-7}$	24.0	$8.06 x 10^{-19}$	$8.06 x 10^{-23}$	$8.06 x 10^{-20}$
$1.67 x 10^{-7}$	25.0	$3.21 x 10^{-19}$	$3.21 x 10^{-23}$	$3.21 x 10^{-20}$
$6.65 x 10^{-8}$	26.0	$1.28 x 10^{-19}$	$1.28 x 10^{-23}$	$1.28 x 10^{-20}$

Table 6: H-band flux conversion table

F_ν [Jy]	H [mag]	F_λ [$Wm^{-2}\mu m^{-1}$]	F_λ [$Wcm^{-2}\mu m^{-1}$]	F_λ [$erg\ s^{-1}cm^{-2}Å^{-1}$]
980	0.0	$1.08x10^{-9}$	$1.08x10^{-13}$	$1.08x10^{-10}$
390	1.0	$4.3x10^{-10}$	$4.3x10^{-14}$	$4.3x10^{-11}$
155	2.0	$1.712x10^{-10}$	$1.712x10^{-14}$	$1.712x10^{-11}$
61.8	3.0	$6.814x10^{-11}$	$6.814x10^{-15}$	$6.814x10^{-12}$
24.6	4.0	$2.713x10^{-11}$	$2.713x10^{-15}$	$2.713x10^{-12}$
9.8	5.0	$1.08x10^{-11}$	$1.08x10^{-15}$	$1.08x10^{-12}$
3.9	6.0	$4.3x10^{-12}$	$4.3x10^{-16}$	$4.3x10^{-13}$
1.55	7.0	$1.712x10^{-12}$	$1.712x10^{-16}$	$1.712x10^{-13}$
0.618	8.0	$6.814x10^{-13}$	$6.814x10^{-17}$	$6.814x10^{-14}$
0.246	9.0	$2.713x10^{-13}$	$2.713x10^{-17}$	$2.713x10^{-14}$
0.098	10.0	$1.08x10^{-13}$	$1.08x10^{-17}$	$1.08x10^{-14}$
0.039	11.0	$4.3x10^{-14}$	$4.3x10^{-18}$	$4.3x10^{-15}$
0.0155	12.0	$1.712x10^{-14}$	$1.712x10^{-18}$	$1.712x10^{-15}$
0.00618	13.0	$6.814x10^{-15}$	$6.814x10^{-19}$	$6.814x10^{-16}$
0.00246	14.0	$2.713x10^{-15}$	$2.713x10^{-19}$	$2.713x10^{-16}$
$9.8x10^{-4}$	15.0	$1.08x10^{-15}$	$1.08x10^{-19}$	$1.08x10^{-16}$
$3.9x10^{-4}$	16.0	$4.3x10^{-16}$	$4.3x10^{-20}$	$4.3x10^{-17}$
$1.55x10^{-4}$	17.0	$1.712x10^{-16}$	$1.712x10^{-20}$	$1.712x10^{-17}$
$6.18x10^{-5}$	18.0	$6.814x10^{-17}$	$6.814x10^{-21}$	$6.814x10^{-18}$
$2.46x10^{-5}$	19.0	$2.713x10^{-17}$	$2.713x10^{-21}$	$2.713x10^{-18}$
$9.8x10^{-6}$	20.0	$1.08x10^{-17}$	$1.08x10^{-21}$	$1.08x10^{-18}$
$3.9x10^{-6}$	21.0	$4.3x10^{-18}$	$4.3x10^{-22}$	$4.3x10^{-19}$
$1.55x10^{-6}$	22.0	$1.712x10^{-18}$	$1.712x10^{-22}$	$1.712x10^{-19}$
$6.18x10^{-7}$	23.0	$6.814x10^{-19}$	$6.814x10^{-23}$	$6.814x10^{-20}$
$2.46x10^{-7}$	24.0	$2.713x10^{-19}$	$2.713x10^{-23}$	$2.713x10^{-20}$
$9.8x10^{-8}$	25.0	$1.08x10^{-19}$	$1.08x10^{-23}$	$1.08x10^{-20}$
$3.9x10^{-8}$	26.0	$4.3x10^{-20}$	$4.3x10^{-24}$	$4.3x10^{-21}$

Table 7: K-band flux conversion table

F_ν [Jy]	K [mag]	F_λ [$Wm^{-2}\mu m^{-1}$]	F_λ [$Wcm^{-2}\mu m^{-1}$]	F_λ [erg $s^{-1}cm^{-2}Å^{-1}$]
620	0.0	$3.84x10^{-10}$	$3.84x10^{-14}$	$3.84x10^{-11}$
247	1.0	$1.53x10^{-10}$	$1.53x10^{-14}$	$1.53x10^{-11}$
98.3	2.0	$6.09x10^{-11}$	$6.09x10^{-15}$	$6.09x10^{-12}$
39.1	3.0	$2.43x10^{-11}$	$2.43x10^{-15}$	$2.43x10^{-12}$
15.6	4.0	$9.66x10^{-12}$	$9.66x10^{-16}$	$9.66x10^{-13}$
6.20	5.0	$3.84x10^{-12}$	$3.84x10^{-16}$	$3.84x10^{-13}$
2.47	6.0	$1.53x10^{-12}$	$1.53x10^{-16}$	$1.53x10^{-13}$
0.983	7.0	$6.09x10^{-13}$	$6.09x10^{-17}$	$6.09x10^{-14}$
0.391	8.0	$2.43x10^{-13}$	$2.43x10^{-17}$	$2.43x10^{-14}$
0.156	9.0	$9.66x10^{-14}$	$9.66x10^{-18}$	$9.66x10^{-15}$
0.0620	10.0	$3.84x10^{-14}$	$3.84x10^{-18}$	$3.84x10^{-15}$
0.0247	11.0	$1.53x10^{-14}$	$1.53x10^{-18}$	$1.53x10^{-15}$
0.00983	12.0	$6.09x10^{-15}$	$6.09x10^{-19}$	$6.09x10^{-16}$
0.00391	13.0	$2.43x10^{-15}$	$2.43x10^{-19}$	$2.43x10^{-16}$
0.00156	14.0	$9.66x10^{-16}$	$9.66x10^{-20}$	$9.66x10^{-17}$
$6.20x10^{-4}$	15.0	$3.84x10^{-16}$	$3.84x10^{-20}$	$3.84x10^{-17}$
$2.47x10^{-4}$	16.0	$1.53x10^{-16}$	$1.53x10^{-20}$	$1.53x10^{-17}$
$9.83x10^{-5}$	17.0	$6.09x10^{-17}$	$6.09x10^{-21}$	$6.09x10^{-18}$
$3.91x10^{-5}$	18.0	$2.43x10^{-17}$	$2.43x10^{-21}$	$2.43x10^{-18}$
$1.56x10^{-5}$	19.0	$9.66x10^{-18}$	$9.66x10^{-22}$	$9.66x10^{-19}$
$6.20x10^{-6}$	20.0	$3.84x10^{-18}$	$3.84x10^{-22}$	$3.84x10^{-19}$
$2.47x10^{-6}$	21.0	$1.53x10^{-18}$	$1.53x10^{-22}$	$1.53x10^{-19}$
$9.83x10^{-7}$	22.0	$6.09x10^{-19}$	$6.09x10^{-23}$	$6.09x10^{-20}$
$3.91x10^{-7}$	23.0	$2.43x10^{-19}$	$2.43x10^{-23}$	$2.43x10^{-20}$
$1.56x10^{-7}$	24.0	$9.66x10^{-20}$	$9.66x10^{-24}$	$9.66x10^{-21}$
$6.20x10^{-8}$	25.0	$3.84x10^{-20}$	$3.84x10^{-24}$	$3.84x10^{-21}$
$2.47x10^{-8}$	26.0	$1.53x10^{-20}$	$1.53x10^{-24}$	$1.53x10^{-21}$

Table 8: I-band surface brightness conversion table

[Jy arcsec^{-2}]	[MJy steradian^{-1}]	[mag arcsec^{-2}]
2250	2.66×10^{4}	0.0
894	1.06×10^{4}	1.0
356	4210	2.0
142	1680	3.0
56.4	667	4.0
22.5	266	5.0
8.94	106	6.0
3.56	42.1	7.0
1.42	16.8	8.0
0.564	6.67	9.0
0.225	2.66	10.0
0.0894	1.06	11.0
0.0356	0.421	12.0
0.0142	0.168	13.0
0.00564	0.0667	14.0
0.00225	0.0266	15.0
8.94×10^{-4}	0.0106	16.0
3.56×10^{-4}	0.00421	17.0
1.42×10^{-4}	0.00168	18.0
5.64×10^{-5}	6.67×10^{-4}	19.0
2.25×10^{-5}	2.66×10^{-4}	20.0
8.94×10^{-6}	1.06×10^{-4}	21.0
3.56×10^{-6}	4.21×10^{-5}	22.0
1.42×10^{-6}	1.68×10^{-5}	23.0
5.64×10^{-7}	6.67×10^{-6}	24.0
2.25×10^{-7}	2.66×10^{-6}	25.0
8.94×10^{-8}	1.06×10^{-6}	26.0

Table 9: J-band surface brightness conversion table

[Jy arcsec^{-2}]	[MJy steradian^{-1}]	[mag arcsec^{-2}]
1670	1.97×10^{4}	0.0
665	7860	1.0
265	3130	2.0
106	1250	3.0
42.0	496	4.0
16.7	197	5.0
6.65	78.6	6.0
2.65	31.3	7.0
1.06	12.5	8.0
0.420	4.96	9.0
0.167	1.97	10.0
0.0665	0.786	11.0
0.0265	0.313	12.0
0.0106	0.125	13.0
0.00420	0.0496	14.0
0.00167	0.0197	15.0
6.65×10^{-4}	0.00786	16.0
2.65×10^{-4}	0.00313	17.0
1.06×10^{-4}	0.00125	18.0
4.20×10^{-5}	4.96×10^{-4}	19.0
1.67×10^{-5}	1.97×10^{-4}	20.0
6.65×10^{-6}	7.86×10^{-5}	21.0
2.65×10^{-6}	3.13×10^{-5}	22.0
1.06×10^{-6}	1.25×10^{-5}	23.0
4.20×10^{-7}	4.96×10^{-6}	24.0
1.67×10^{-7}	1.97×10^{-6}	25.0
6.65×10^{-8}	7.86×10^{-7}	26.0

Table 10: H-band surface brightness conversion table

[Jy arcsec^{-2}]	[MJy steradian^{-1}]	[mag arcsec^{-2}]
980	$1.16x10^{4}$	0.0
390	4610	1.0
155	1830	2.0
61.8	730	3.0
24.6	291	4.0
9.8	116	5.0
3.9	46.1	6.0
1.55	18.3	7.0
0.618	7.3	8.0
0.246	2.91	9.0
0.098	1.16	10.0
0.039	0.461	11.0
0.0155	0.183	12.0
0.00618	0.073	13.0
0.00246	0.0291	14.0
$9.8x10^{-4}$	0.0116	15.0
$3.9x10^{-4}$	0.00461	16.0
$1.55x10^{-4}$	0.00183	17.0
$6.18x10^{-5}$	$7.3x10^{-4}$	18.0
$2.46x10^{-5}$	$2.91x10^{-4}$	19.0
$9.8x10^{-6}$	$1.16x10^{-4}$	20.0
$3.9x10^{-6}$	$4.61x10^{-5}$	21.0
$1.55x10^{-6}$	$1.83x10^{-5}$	22.0
$6.18x10^{-7}$	$7.3x10^{-6}$	23.0
$2.46x10^{-7}$	$2.91x10^{-6}$	24.0
$9.8x10^{-8}$	$1.16x10^{-6}$	25.0
$3.9x10^{-8}$	$4.61x10^{-7}$	26.0

Table 11: K-band surface brightness conversion table

[Jy arcsec^{-2}]	[MJy steradian^{-1}]	[mag arcsec^{-2}]
620	7320	0.0
247	2930	1.0
98.3	1160	2.0
39.1	462	3.0
15.6	184	4.0
6.20	732	5.0
2.47	29.3	6.0
0.983	11.6	7.0
0.391	4.62	8.0
0.156	1.84	9.0
0.0620	0.732	10.0
0.0247	0.293	11.0
0.00983	0.116	12.0
0.00391	0.0462	13.0
0.00156	0.0184	14.0
6.20x10^{-4}	0.00732	15.0
2.47x10^{-4}	0.00293	16.0
9.83x10^{-5}	0.00116	17.0
3.91x10^{-5}	4.62x10^{-4}	18.0
1.56x10^{-5}	1.84x10^{-4}	19.0
6.20x10^{-6}	7.32x10^{-5}	20.0
2.47x10^{-6}	2.93x10^{-5}	21.0
9.83x10^{-7}	1.16x10^{-5}	22.0
3.91x10^{-7}	4.62x10^{-6}	23.0
1.56x10^{-7}	1.84x10^{-6}	24.0
6.20x10^{-8}	7.32x10^{-7}	25.0
2.47x10^{-8}	2.93x10^{-7}	26.0

5. Examples

1.

Given a source with a flux of 0.9mJy at 1350Å, convert this flux to erg $s^{-1}cm^{-2}Å^{-1}$.

From section 3, Table 1, we see that the conversion constant β is $3x10^{-13}$ and the wavelength is 1350Å = 0.135µm. Thus

$F_\lambda=3x10^{-13}$ x $9x10^{-4}$ / 0.135^2 = $1.48x10^{-14}$erg $s^{-1}cm^{-2}Å^{-1}$.

2.

Given a V magnitude of 15.6, and knowledge that V-K=2.5 in the UKIRT system, estimate the flux in Jy at K.

Since V-K=2.5 we know that K=13.1. From Table 2, the zero-point flux in the UKIRT system for K is 657Jy. Thus the 2.2µm flux is

$F_\nu=10^{-13.1/2.5}$ x 657 = $3.8x10^{-3}$Jy.

3.

Given a surface brightness of 21.1 magnitudes $arcsec^{-2}$ at J, convert this into Jy $arcsec^{-2}$ and into MJy $steradian^{-1}$.

Taking the zero-point for the J band from Table 2, we determine that the surface brightness is $10^{-21.1/2.5}$ x 1670 = $6.06x10^{-6}$Jy $arcsec^{-2}$, or $6.06x10^{-6}$/0.084616 = $7.17x10^{-5}$MJy $ster^{-1}$.

4.

Given a flux at 0.9µm of $2.3x10^{-7}$Jy, estimate the I magnitude.

$2.3x10^{-7}$Jy is less than $2.3x10^{-1}$Jy by three powers of a hundred, or 15 magnitudes. From Table 3 we see that 0.25Jy is equivalent to an I-band magnitude of 9.89. Thus $2.3x10^{-7}$ is roughly 15 magnitudes fainter than this, or of order I=24.9.