Reference Wavelengths for ISO: CAM and PHOT Filters

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Reference Documents

R1)	ISO Reference wavelengths	SAI/96-240/Dc, 18/Dec/96
R2)	Golay 1974 in "Introduction to Astronomical Photometry", Ch. 2	

1 Introduction

This document summarises discussions held over the last three months or so, for the most part in the context of the monthly Cross-Calibration meetings, on how to present ISO photometric measurements. Specifically, it will specify the manner in which in-band fluxes will be converted to monochromatic flux densities, and the choice of wavelengths to which these flux densities will be referred.

2 Determining Flux Densities and Reference Wavelengths

The subject of the conversion of a heterochromatic photometric measurement to a monochromatic one has been sumarised in R1, and full details can be found in R2. Following extensive discussion, the decision was made to adopt the IRAS convention, where the conversion is performed assuming a constant energy spectrum, i.e. $\lambda E(\lambda) = \nu E(\nu) = const$. This has the advantage of making the results immediately comparable to IRAS data (though the filters are not identical), and the drawback that significant correction factors will have to be applied to most data, as was the case with the IRAS data, since most of the sources observed do not have a constant energy spectrum. These correction factors can be as large as $\sim 40\%$, and are largest for the broadest filters.

Alternative choices were:

1. to give only the in-band fluxes (in W/cm^2): these have the advantage of directly proportional to the what is measured and to be expressed in physical units, but since the depend of the filter bandwidth they cannot easily be compared to one another or to other data.
2. to give the ratio of the in-band flux of the source to that of a reference source expressed in magnitudes: these are awkward at best, mostly because they are not expressed in physical units. Furthermore, there is no single reference source that could span the complete ISO wavelength range.
3. to assume a model Sirius spectrum: this would produce correct results for nearly all normal stars, but incorrect results for peculiar stars, galaxies, and other objects. This is the scheme adopted by MSX, whose output catalog will consist primarily of stars (M. Cohen, private communication).

Options (1) and (2) would leave the conversion to monochromatic flux density entirely up to the user.

From the definition of isophotal wavelength, $\lambda_{\rm iso}$,

$$E \equiv \int_a^b E(\lambda)T(\lambda)\mathrm{d}\lambda = E(\lambda_{\rm iso}) \int_a^b T(\lambda)\mathrm{d}\lambda, \qquad (1)$$

where E is the measured in-band flux, and $T(\lambda)$ is the spectral response of the system, and with $E(\lambda) = 1/\lambda$, it follows that

$$E(\lambda_{\rm iso}) = \frac{E}{\int_a^b T(\lambda)\mathrm{d}\lambda}, \qquad (2)$$

where the denominator is a property of the photometric system alone. And finally, to convert from $E(\lambda_{\rm iso})$ to $E(\lambda_{\rm ref})$ we use the relation

$$E(\lambda_{\rm ref}) = \frac{\lambda_{\rm iso}}{\lambda_{\rm ref}} E(\lambda_{\rm iso}). \qquad (3)$$

Note that equations (2) and (3) define a linear relation between the in-band flux, E, and the flux density at the reference wavelength, $E(\lambda_{\rm ref})$.

From a formal point of view the choice of reference wavelengths is absolutely arbitrary. A reasonable choice of $\lambda_{\rm ref}$, however, will give *an idea* of the spectral energy distribution (SED) of the source, but in order to determine the true SED the user must convert $\lambda_{\rm ref}$ and $E(\lambda_{\rm ref})$ to $\lambda_{\rm iso}$ and $E(\lambda_{\rm iso})$ by using a known or assumed source spectral shape. For this purpose, "color correction tables" will be computed which will give correction factors and observed colours for many different types of energy distributions (namely power laws with different exponents, and Plank laws with a wide range of temperatures).

For the moment, and for the purpose of data presentation, a set of reference wavelengths has been chosen such that

1. they would clearly identify the filter, in particular where the filter is associated with a specific spectral band or line,
2. they are easy to remember numbers,
3. they are close to the $\lambda_{\rm iso}$ for either an $E(\lambda) = 1/\lambda$ spectrum or for Sirius.

The reference wavelengths that deviate the most from either isophotal wavelength are the ones for the IRAS filters, for which the IRAS wavelengths have been adopted. The reference wavelengths are tabulated in Tables 1 and 2 for CAM and PHT filters, respectively.

Table 1: CAM reference wavelengths

name	ref. λ	purpose	name	ref. λ	purpose
sw1	3.6	cosm.	lw1	4.5	Gen. Pur.
sw2	3.3	PAH	lw2	6.7	Gen. Pur.
sw3	4.4	Gen. Pur.	lw3	14.3	Gen. Pur.
sw4	2.8	Gen. Pur.	lw4	6.0	PAH
sw5	4.0	Gen. Pur.	lw5	6.8	Gen. Pur.
sw6	3.7	Gen. Pur.	lw6	7.7	PAH
sw7	3.0	Gen. Pur.	lw7	9.6	Silicates
sw8	4.05	Brα	lw8	11.3	PAH
sw9	3.9	Brα comp.	lw9	14.9	Gen. Pur.
sw10	4.6	CO fund.	lw10	12	IRAS
sw11	4.26	CO_2			

Table 2: PHT reference wavelengths

name	ref. λ	purpose	name	ref. λ	purpose
P3.29	3.3	PAH	C50	65	Gen. Pur.
P3.6	3.6	cosm.	C60	60	Gen. Pur.
P4.85	4.8	Gen. Pur.	C70	80	Gen. Pur.
P7.3	7.3	Gen. Pur.	C90	90	Gen. Pur.
P7.7	7.7	PAH	C100	100	Gen. Pur.
P10	10.0	Silicates	C105	105	Gen. Pur.
P11.3	11.3	PAH	C120	120	Gen. Pur.
P11.5	12	IRAS	C135	150	Gen. Pur.
P12.8	12.8	[NeII]	C160	170	Gen. Pur.
P16	15.0	Gen. Pur.	C180	180	Gen. Pur.
P20	20	Gen. Pur.	C200	200	Gen. Pur.
P25	25	IRAS			
P60	60	Gen. Pur.			
P100	100	Gen. Pur.			