ISOCAM Calibration Accuracies Document

Diego Cesarsky and Joris Blommaert

5 December 2000

1 Introduction

This note gives an overview of the accuracy achieved by the automatic data processing of data taken with the mid-infrared (2-17 μm) camera ISOCAM. More specifically, we present in Section 2 the accuracies achieved in the current version of the ISOCAM OLP (V9.5) whereas section 3 discusses how the preceding uncertainties can be improved with the use of CAM's Interactive Analysis (CIA).

Section 4 gives information on the planned enhancements of the OLP software. Since all ISO data will eventually be reprocessed with the final OLP software, section 4 gives hints as to the final status of the ISO PMA.

2 Accuracy of ISOCAM's OLP V9.5 products

2.1 Photometric accuracy

The uncertainties for the flux accuracy in Table 1 are given for sources observed in the central part of the detector array. The values are based on the analysis of observations of standard stars.

Note that although Polarization Observations (CAM05) are handled by the current version of the off–line software, the corresponding products have not been formally validated yet.

Table 1: Photometric Accuracy of V9.5

CAM AOT	$>$ 100 mJy	$<$ 100 mJy	Notes
CAM01 (staring)	20%	30%	–
CAM01 (micro raster)	10%	20%	1
CAM03	20%	30%	–
CAM04 (one way scan)	40%	40%	2
CAM04 (back and forth scan)	30%	30%	2
CAM05	–	–	

Table NOTES:

1. The better accuracies can be achieved by the SLICE package within CIA (results soon to become available as post–processed archived products)
2. The distinction between one way and back-and-forth scans are nolonger relevant to LWS data processed using the OLP9.5 transient corrector

General notes:

- The fluxes for point sources in the CPSL (CAM Point Source List FITS file) are derived by PSF–fitting in the image. These photometry values can have larger errors than stated in Table 1 if the fitting is incorrect.

- Because of wheel-jitter the "library" FlatField may not cover the same detector region as the sky image does. The effect is small in the central region of the array where the uncertainty is less than 1%. The uncertainty becomes however very large near the edges (up to a factor of 5 in extreme cases), where vignetting is important (for example in the case of a 6″ PFOV measurement).
- Most CVF observations are performed after a discrete filter observation thus implying a large decrease in the incident flux on the detector. This may lead to important transient effects that may last several readouts and hence several wavelength steps. The down transient is not always well corrected by the transient algorithm in OLP9.5; the result is a larger than true flux for the first wavelength steps.
- CVF observations are affected by the existence of "ghosts", i.e. bogus images generated by multiple reflections between the detector and the CVF surface. Ghosts can appear away from the source image but may also fall onto (and surround) the sky image, depending on the actual position of the source on the detector.

2.2 Astrometric accuracy

The most obvious source of astrometric errors is the absolute pointing error of the ISO spacecraft (roughly 1.5 arcsec). This error will affect *all* pixels of the detector equally.

CAM's astrometrical calibration is based on the premise that the optical axis of the telescope intersects the detector at pixels [16.5,16.5]. This is true when the lenses are centered with the optical axis. However, the lens wheels have a small amount of play within each motor step and hence a lens wheel may not come to rest exactly at its nominal position to better than a fraction of a step (one wheel turn equals 480 motor steps). This may lead to a bending of the optical axis along a direction *perpendicular* to the detector's columns, i.e. along the direction of the spacecraft Y–axis. As with the pointing error, all pixels are affected in the same manner.

A third error element is due to the "pin–cushion" effect: the lens magnification changes as a function of the distance from the optical axis on the detector plane. The distortion is about 1 PFOV in the corners of the array for a 6″ PFOV measurement. The distortion is negligible in the case of a 1.5″ PFOV measurement.

The estimates of these errors are shown in Table 2:

Table 2: Astrometry Accuracy of V9.5

Channel	Pointing error	Wheel Jitter
SW	$\simeq$ 1.5 arcsec	$\simeq 1.5\times$ PFOV
LW	$\simeq$ 1.5 arcsec	$\simeq 1.5\times$ PFOV

2.3 Spectral accuracy

Table 3 gives the estimated error, in microns, between the indicated wavelength and the true wavelength. The indication "negligible" means that the error, if any, is at most a tenth of a CVF step. The wavelength depends weakly on the column on which the source falls, with a maximum shift of 1 step at the edges of the array. There is no array line-dependence observed.

3 Improvements of the accuracies with interactive analysis

3.1 Photometric accuracy

It was established during the operational lifetime of ISOCAM that observations of the same source have a very good repeatability. Indeed, repeated photometric observations on HIC89474 throughout the whole

Table 3: Spectral Accuracy of V9.5

CVF Segment	Error central pixels	Error border pixels
SW CVF	negligible	$\simeq$ Wavelength step
LW short CVF	negligible	$\simeq$ Wavelength step
LW long CVF	negligible	$\simeq$ Wavelength step

ISO lifetime give a standard deviation of around 2% for both the LW and SW detectors.

Observations of a larger set of standard stars which were used to determine the absolute flux calibration give a RMS of around 5% for both detectors. It was also found that the LW detector is very linear over a very large range of flux levels from a few mJy up to the saturation level.

The important finding here is that the signal needs to be stabilized to improve on the photometric accuracy. Current routines in CIA are capable of correcting the observed number of digital counts to within 1–2 % of the expected number of counts had the detector responded instantaneously to the incident light. The transient algorithm has now been introduced in OLP.

The CVF Spectral Response Function was established based on several observations of standard stars. The analysis shows that these are highly reproducible (per observation) and accurate, i.e. the known fluxes of the standard stars are correctly estimated from the observations. The RMS of repeated measurements is 3% for the SW part and 4% for the 2 LW CVF segments. A systematic comparison of fluxes derived by OLP for the calibration standard stars reveals that OLP fluxes are systematically lower than the expected star model fluxes. This is puzzling as those very model stars were used to establish the calibration of the CVFs. A very likely explanation is that the calibration curves were established by aperture photometry whereas OLP point source detection is based upon PSF fitting algorithms. It would appear then that aperture photometry should yield more accurate results than currently found by OLP.

One other aspect which one has to handle with great care is to exclude the ghost image. Including it when applying aperture photometry may lead to errors of up to 25%.

It was also mentioned in section 2.1 that the FlatField is very accurate in the central part of the array but can be off by a factor of 2 or more at the edges. This effect cannot, for the time being, be corrected for staring observations. However in the case of rasters with sufficient background and redundancy one can build a FF from the very observations being analyzed.

3.2 Astrometric accuracy

The pin–cushion effect was mentioned in Section 2.2. There are tools in CIA to correct for this effect. Note that in the case of rasters with redundancy this correction has two beneficial results:

1. Celestial coordinates of observed sources are more precise
2. Fluxes of multiply detected sources are more accurate as the "sum" source is constructed on celestial coordinates.

4 Expected Accuracy of ISOCAM's final OLP products

The next version of OLP (to be OLPV10) will not differ substantially from the current version and hence no bettering of errors is to be expected. However, steps will be taken to the effect that the errors quoted in the data products are more in line with the actual errors (currently, "true" errors tend to be higher than the quoted errors, which are statistical errors and hence do not contain any systematic effects).

A possible enhancement for OLPV10 will be the inclusion of the Distorsion Correction algorithm, see 3.2.

5 Reference Documents

- The ISOCAM Calibration Error Budget Report
  A. Biviano
  Version 3.1 (August 14, 1998)

- ISOCAM Photometry Report
  J. Blommaert
  Version 2.1 (October 6, 1998)

- ISOCAM CVF Calibration Report
  A. Biviano, B. Altieri, J. Blommaert, F. Boulanger,
  D. Cesarsky, L. Metcalfe, K. Okumura, W. Reach
  Version 1.1 (May 20, 1998)

- OLP 7 Validation Report and Caveats
  D. Cesarsky and S. Ott

- OLP9.5 Validation Report and Caveats
  D. Cesarsky

- ISOCAM Data Users Manual
  R. Siebenmorgen, M. Sauvage, J.-L. Starck, D.A. Cesarsky,
  J. Blommaert, S. Ott
  Version 4.0 (SAI/95-222/Dc)