CALIBRATION OF ISOPHOT-S CHOPPED MEASUREMENTS

Jose Acosta–Pulido
ISO Data Center, ESA Astrophysics Science Division, VILSPA
Instituto de Astrofisica de Canarias

March 8, 1999

1 Introduction

Chopped observations with the sub–instrument ISOPHOT-S were extensively performed on mostly faint sources (for statistics see Table 1 and Fig. 1). The response of ISOPHOT-S detectors after each flux step is very slow when exposed to low illumination levels. Due to these slow detector transients, an important fraction (theoretically up to 40%) of the difference signal between the chopper on-source and off-source signals is lost. This causes a large uncertainty in the photometric calibration when no corrections are made and assuming a fixed responsivity for the PHT-S detectors.

A method to correct for the signal loss is by applying the Fouks–Schubert detector transient correction (Acosta–Pulido, Gabriel & Castañeda, 1999), which gives a prediction for the true signal difference based on a physical detector model. This procedure works properly in a limited source flux range, where the flux step is not so high that hook effects appear. In addition, a relatively high signal-to-noise ratio and sufficiently long chopper plateaux are required for the fitting procedure. However in most chopped observations the signal-to-noise ratio is low: often the source is only barely detected upon a low background level.

In this report we present a new approach to calibrate chopped PHT-S observations. The method is based on a direct comparison between the difference signal of the source and the difference signal of a calibration standard of similar brightness. This method does not require any model fitting, which introduces less systematic uncertainties from model assumptions in the calibration process.

Rectangular		Triangular		Sawtooth		Total
#	%	#	%	#	%	#
227	57	169	43	2	0	398

Table 1: Number and percentage of chopped ISOPHOT-S measurements per chopper mode during the ISO mission

2 Method

2.1 Calibration Measurements

We have measured relatively faint calibration stars from $m_K = 1.65$ to $m_K = 7.54$. It should be noticed that there is a clear bias on the shape of the spectral energy distribution: the stellar

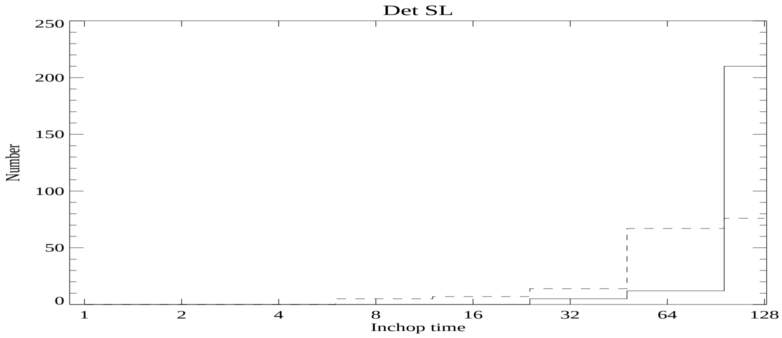

Figure 1: Number of measurements perfomed using ISOPHOT-S in chopping mode vs the time per chopper plateau. Solid line represents rectangular chopping and dashed line triangular chopping.

Star Name	m_K	Sp.T.	TDTNR	Chopp.Mode	t_{res}[s]	t_{chop}[s]	t_{exp}[s]
HR6464	1.65	M0III	SL0163601102	Tria	4	16	1024
HR5986	2.73	F8IV-V	SL0166400502	Tria	8	32	1024
HR6817	3.77	K1III	SL0167800801	Rect	16	64	1024
HR6817	3.77	K1III	SL0167800902	Tria	16	64	1024
HR6847	4.79	G2V	SL0169300401	Rect	32	128	2048
HR6847	4.79	G2V	SL0169300502	Tria	32	128	2048
HD132142	5.79	K1V	SL0163600901	Rect	32	128	2048
HD132142	5.79	K1V	SL0163601002	Tria	32	128	2048
HD172323	6.59	F9V	SL0168501601	Rect	32	128	2048
HD184400	7.54	F5	SL0184604401	Rect	32	128	4096

Table 2: List of used calibration observations

spectra are always fainter towards the longer wavelengths. The calibration observations are listed in table 2.

2.2 Data reduction

The data reduction of calibration measurements was done using PIA version 7 routines with the following processing steps:

Corrections at ERD level:

- Deglitching using two thresholds algorithm.

Processing ERD $\rightarrow$ SRD: Ramps were split into 3 and 5 pieces for those measurements with t_{reset} = 16 and 32, respectively.

Corrections at SRD level:

- Deglitching

Processing SRD $\rightarrow$ SCP: Signal difference is computed separately from medians of all values corresponding to *on* and off–source chopper positions. The final result is the signal difference $on - off$ per pixel.

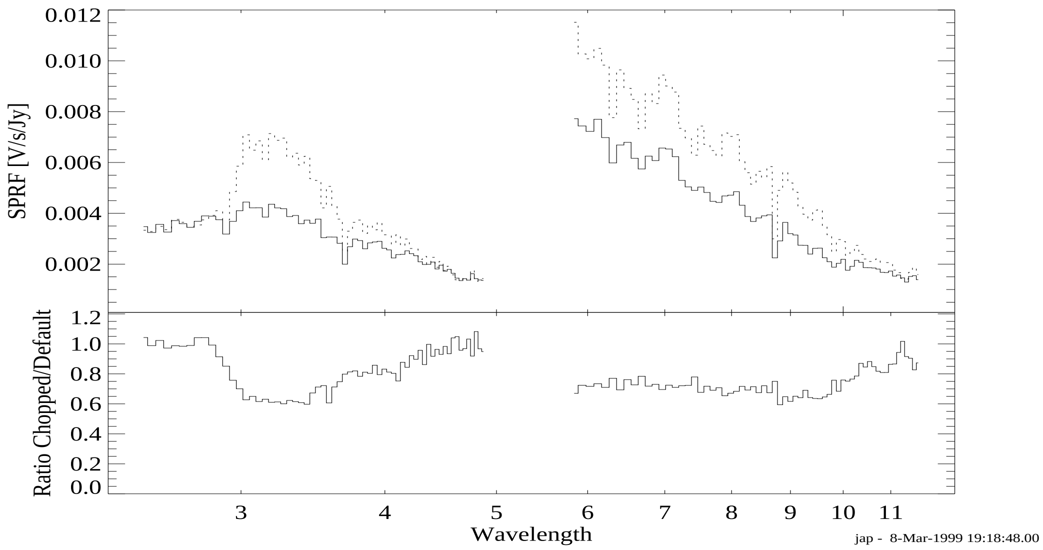

Figure 2: Comparison of spectral response functions as derived from staring (dotted line) and chopped observations (continuous line).

3 Spectral response function

A spectral response function (hereafter **SPRF**) is determined from the ratio between the signal difference ($on - off$) and the model flux for each calibration star. The model fluxes are taken from M. Cohen and P. Hammersley inputs. We have derived a mean value for the SPRF (see Fig. 2) using inputs from all calibration standard measurements. A comparison between the SPRF derived in this work and the SPRF obtained from staring calibration observations shows differences up to 30–40% in the regions 3–3.5 μm and 5.9–10 μm.

3.1 Signal dependent correction

We noticed that the individual SPRFs vary systematically with the brightness of the calibration stars. The variation can be as large as 20% for certain pixels, especially those in the middle of the two arrays (SS/SL). We decided to introduce a first order correction to the mean SPRF which is only a function of the difference signal. This correction is based on the fact that the difference signal corresponds to first approximation to the brightness of the source plus background. The background in the ISOPHOT-S wavelength range is dominated by the Zodiacal Light which is detectable only at the longest wavelengths. The brightness level of the background is so low that the time constant of the transient of the background signal is much longer than the integration time per plateau.

We computed the ratio between the SPRFs derived from each individual measurement and the average SPRF. We looked for a linear correlation between these ratios and the signal difference between on and off positions (in log scale), as described in the following expression:

$$f^j_{corr} = A^j_0 + A^j_1 \ log(S^j_{on} - S^j_{off}); \quad SPRF^j_c =< SPRF >^j_{mean} f^j_{corr}; \ \ j = 1,128$$

To improve the fit we have rejected any point deviating by more than 5σ. The derived coefficients are plotted in Fig. 3.

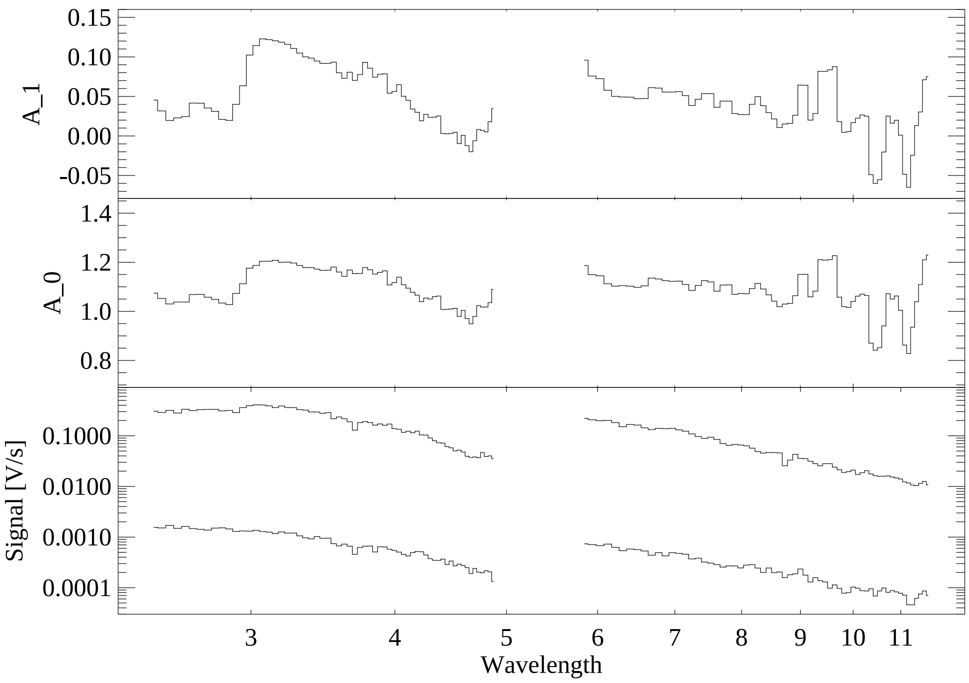

Figure 3: The first order correction to the mean chopped SPRF for all ISOPHOT-S pixels. The coefficients A_0 and A_1 (see text) are plotted in the middle and top panels, respectively. We also plotted the validity range of signals where the correction was derived from in the bottom panel.

4 Performed tests

4.1 Self–consistency check

All calibration star measurements were calibrated using the two approaches described above and compared to the theoretical models, the results are presented in Fig. 4. It can be seen that the spectra calibrated with the mean SPRF are within 20% of the prediction. Addition of the first order corrections improves the consistency to better than 10%. The faintest star HD 184400 is an exception, which can be attributed to a non–detection of the stellar flux towards the end of the long wavelength part of the array.

4.2 Absolute photometry

An independent test was done by comparing the fluxes derived with the calibration method described here and the values obtained from ISOCAM LW2 filter measurements of a large set of normal galaxies from Helou et al4s GT program (see Fig. 5). The agreement between the two calibration is within 20%. This part of the work was done by Dr N. Lu.

4.3 Consistency with Fouks–Schubert transient model

We have checked the consistency of the new method by using the transient correction based on the Fouks–Schubert model. Firstly, we corrected a triangular chopped measurement for chopped signal losses using Fouks–Schubert method as implementated in PIA. Secondly, we derived a corresponding SPRF by applying the Fouks–Schubert transient correction to the chopped measurements of calibration stars (see Table 2). The PHT-S spectrum calibrated according to this scheme is presented in Fig. 6.

Also presented in Fig 6 are the PHT-S spectra of the same source which has been calibrated using the *default* SPRF and using the method presented in this work. The default SPRF is taken from the PHT-S Cal-G file SPECAL (OLP version 7, see PHT-IDUM), which was derived from staring observations of calibration standards. It is important to notice that this default SPRF is likely affected by transient effects.

It can be seen in Fig. 6 that the new calibration method produces a PHT-S spectrum consistent with the one derived using the Fouks–Schubert transient correction method. The agreement with the spectrum derived with the *default* SPRF is poor.

References

[1] J.A. Acosta–Pulido, C. Gabriel, and H.O. Castanñeda, (1999) *Experimental Astronomy*, in press.

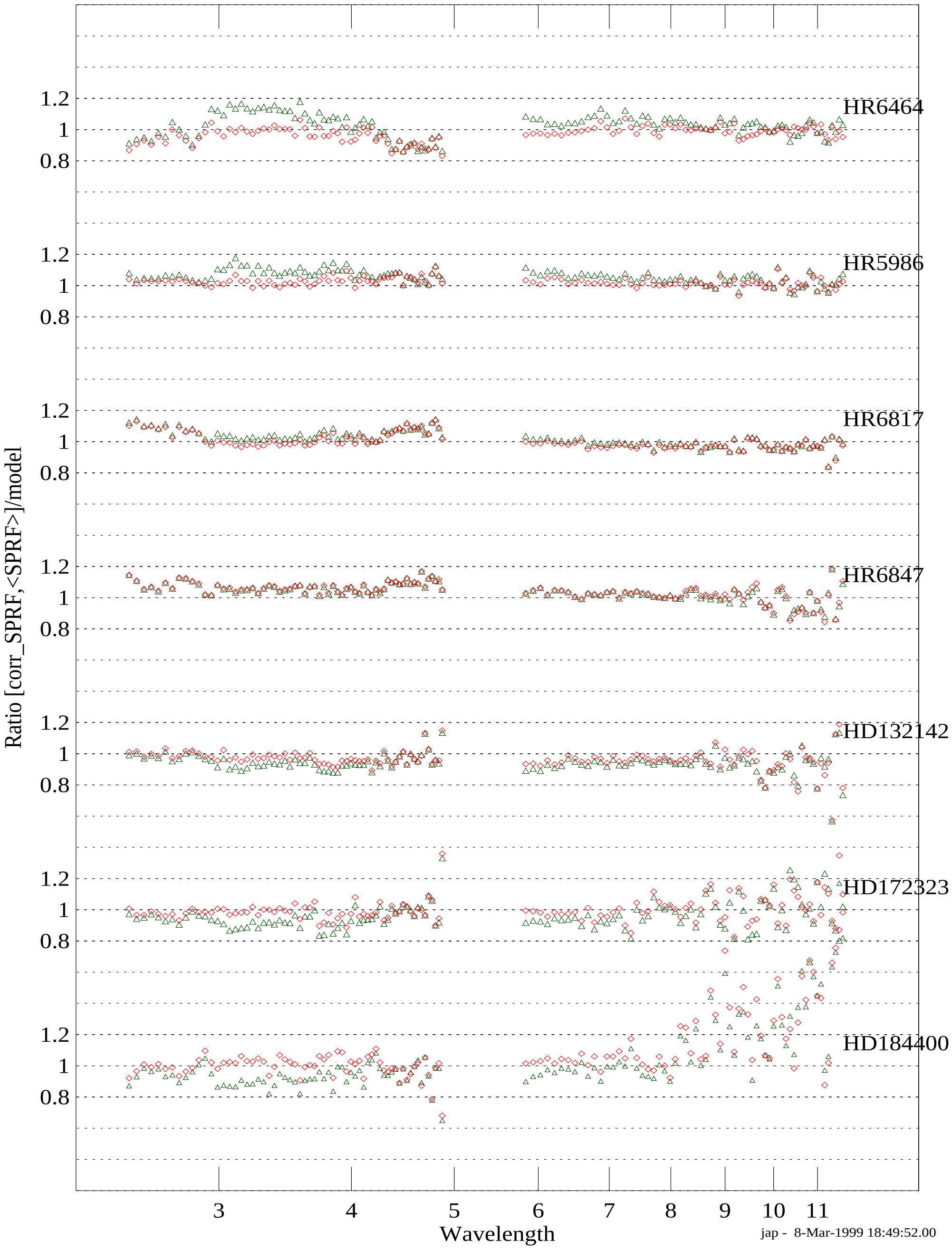

Figure 4: Ratio between the calibration standars spectra and the models. The SPRF derived in this work is used to calibrate the measurements in two ways: using the mean SPRF (triangles) and including the first order correction (diamonds).

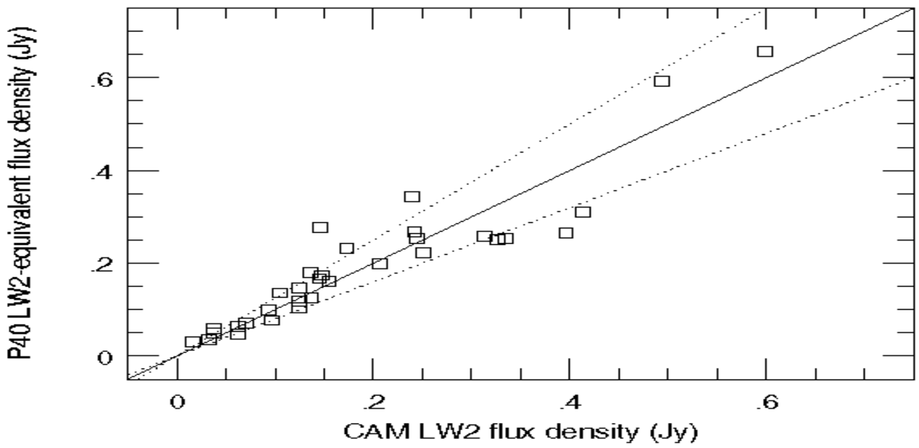

Figure 5: Comparison of ISOCAM LW2 filter and ISOPHOT-S measurements calibrated with the method described in this report. The solid line is the identity and the dotted lines indicate ± 20% deviation from the identity. This graph is a courtesy from Dr N. Lu (IPAC).

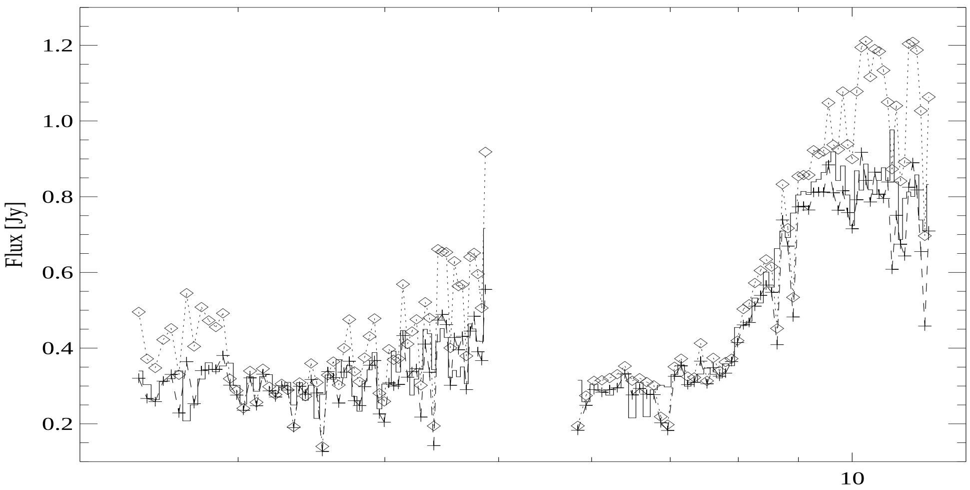

Figure 6: Comparison between the calibration method proposed in this work and the Fouks-Schubert transient correction method. The meaning of the symbols is as follows: the new calibration is represented by the continuous line (histogram type); transient corrected data and calibrated by the transient–free SPRF and the *default* SPRF are represented by crosses (joined by dashed line) and diamonds (joined by dotted line), respectively.