New method to correct ISOCAM-LW transient effects: First results

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Abstract

Up to now, the photometric accuracy of results obtained from the LW channel of ISOCAM is in the general case not better than ∼10%. This is mainly due to limitations of the models commonly used to process the data (Abergel et al. 1998).
We present a new approach based on an analytical inversion of the model of Fouks and Schubert (1995) developed for the PHT-S detectors of ISOPHOT (see also Coulais and Abergel 1998). The first results for extended emission are obtained for steps of flux due to changes of filters, and for CVF scans. The accuracy of the correction appears ∼1%. For CVF observations, the shape of the continuum is corrected over the full spectral range of observation. Compared to previous methods, the computing times are reduced by a factor ∼10-20.

1 Introduction

The old "IAS method" allows a correction of short-term transients, without any parameter adjustment (Abergel et al., 1998). However, the correction is actually strongly limited by the precision of the model of the response which is clearly oversimplified. It fails especially:

1. For downward and upward strong steps, since the model is symmetrical while the response is not,
2. For downward transients to the dark levels since the model assumes exponential-like decrease of the signal while the decreases appear rather hyperbolic,
3. For pixels with high gradient of illumination (especially point sources) since the model neglects the charge coupling.

The detector of the long wavelength channel of the ISOCAM camera is a Gallium doped Silicon photo-conductor hybridized by Indium bump. We have recently shown that the Fouks and Schubert model developed for the Si:Ga detectors of the PHT-S spectrometer of ISOPHOT allows spectacular fitting are obtained for downward and upward steps (Coulais and Abergel 1998). The parameters likely depend on the pixel number (especially at the edges of the detector) while they seem constant over the life of ISO (to be checked properly). In this preliminary report, we test this approach to correct the ISOCAM-LW data. We only considere illuminations with low amplitude spatial structures (zodiacal background, cirrus with zodiacal background...). For point sources, the Fouks-Schubert model actually fails since it does not take into account the charge coupling between pixels.

2 Inversion of the Fouks-Schubert model

Let us consider an observation made of N readouts. The integration time per readout, $t - t_n$ (t is the time at the end of the integration), t_n at the beginning, may depends on n. During each integration , we assume (1) that one given pixel sees the same point in the sky and (2) that the configuration of the instrument is constant. The effects due to the jitter during the integration and to commanded changes of the pointing which may occur during an integration are neglected.

Let:
J_{n-1}^{∞} and J_n^{∞} be the values of the sky brightness during integrations $n-1$ and n (Units: ADU/gain/s), also equal to the response after complete stabilisation (in the general case never achieved),
J_{n-1}^{final} be the response at the end of integration $n-1$ (Units: ADU/gain/s), also equal to the measured response of integration $n-1$.

The Fouks-Schubert model allows to calculate the measured response at the end of the integration number n (at time t) from the values of J_n^{∞}, J_{n-1}^{∞} and J_{n-1}^{final}:

$$J_n(t) = \beta J_n^{\infty} + \frac{(1-\beta)(J_n^{ini} - \beta J_n^{\infty})J_n^{\infty}}{J_n^{ini} - \beta J_n^{\infty} + (J_n^{\infty} - J_n^{ini})exp(-(t-t_n)/\tau)}, \tag{1}$$

with $\tau = \lambda / J_n^{\infty}$.

J_n^{ini} is the response just after the beginning of integration n, and is calculated using:

$$J_n^{ini} = J_{n-1}^{final} + \beta(J_n^{\infty} - J_{n-1}^{\infty}). \tag{2}$$

The transient correction consists to compute, for n going from 0 to N-1, J_n^{∞} from the measured responses $J_n(t)$. The easiest way to invert the equation is to develop to the second order the exponential in equation 1. Therefore we assume that $(t-t_n)/\tau$ is smaller than 1. Equation 1 become a polynomial at the third order in J_n^{∞}.

For integration n, J_n^{∞} is computed analytically from $J_n(t)$, J_{n-1}^{∞} and J_{n-1}^{final} without any fitting. For one given pixel, a complete correction is made integration by integration. It is necessary to initialise the values of J_{-1}^{final} and J_{-1}^{∞}, equal to the final and stabilised response of the integration before the first readout of the observation. Practically, if it is possible to assume that the first

readouts are stabilised, we have: $J_{-1}^{final} = J_{-1}^{\infty} = J_0(t)$. The values of β and λ are adjusted using calibration observations (see Coulais and Abergel 1998). In the example presented below, we use: β= 0.55 and λ= 520. These values still have to be checked. They are assumed constant for all pixels; we know it is NOT the case.
As for the old "IAS model", the correction is made readout by readout. Clearly this is NOT optimal, since we do not take into account the fact that the sky brightness does not change during one given configuration of the camera (typically from a few to 100 radouts or more). All fluctuations of signal are considerd as real, therefore the noise seems increase by a factor $1/\beta$.

3 First Results

See Figs 1, 2, 3.

4 Conclusion

It seems we are handling the right model to correct the short-term transients of CAM-LW data. Compared to the "old" IAS model the photometric accuracy of the correction is increased by a factor $\sim$10, while the computing time is decreased by more than 10.
Systematic tests still have to be done, especially to characterise the pixel to pixel variations of the parameters β and λ and the influence of the uncertainty on the dark level. The correction actually fails for point sources, which sould be due to charge coupling. Glitches with memory effect cannot be corrected with this method, since there is no simple relationship between the amplitude of the glitch and the time constants observed after the impact. Finally the problem of long term drifts, which is known to affect typically 5-10% the flux above the dark level with typical time scales of hours, is still opened (temperature variations?).
We are also working on methods to correct the data sky configuration by sky configuration, and not readout by readout (in collaboration with the Laboratoire des Signaux et Systèmes, Sup'Elec).

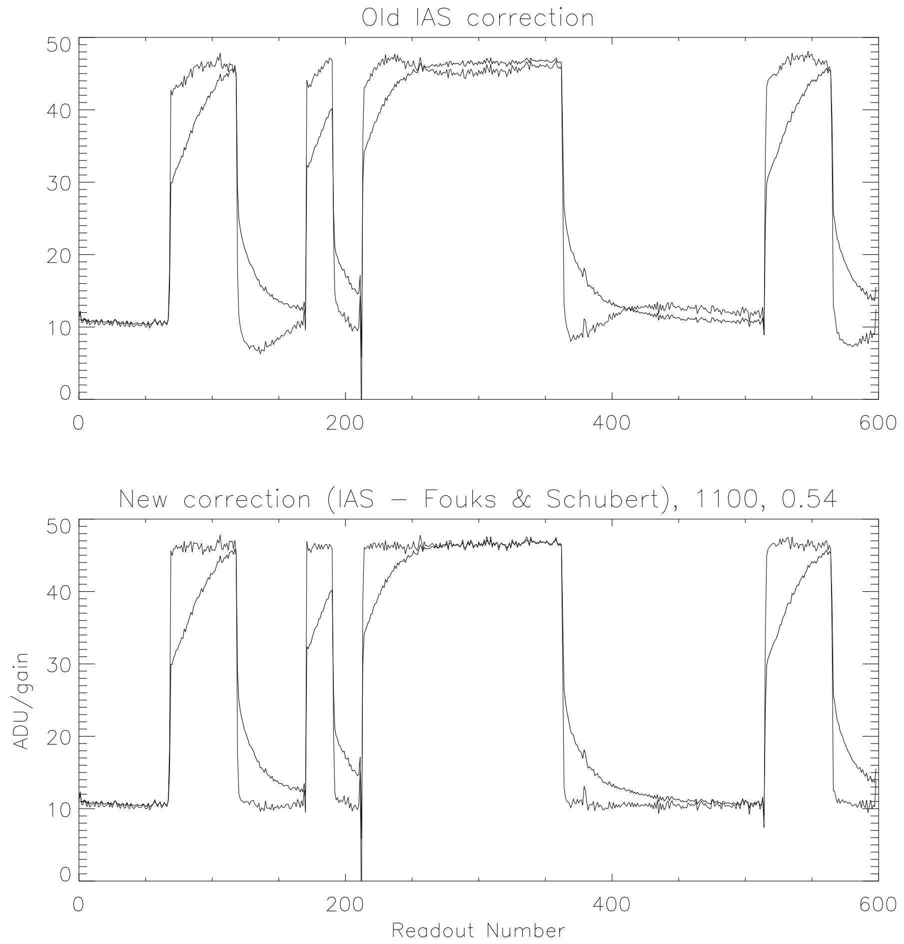

Figure 1: Comparison of the old IAS method with the new method. The mean value of the central square is plotted as a function of the readout number. These data are taken from revolution 16 of the PV phase. The zodiacal background was continuously observed, and the input sky brightness modulated by moving the filter wheel. The integration time per frame was 2.1 s.

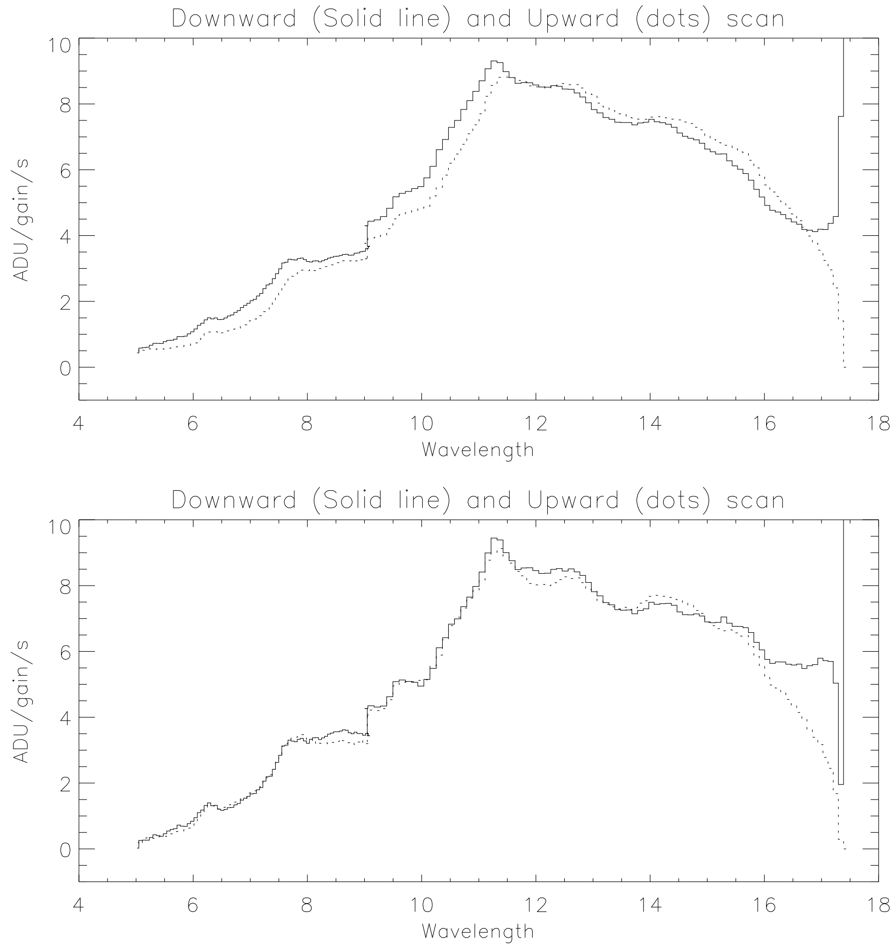

Figure 2: Upward and downward full CVF scans (Mean value of the 1010 central square), with no correction (Upper Pannel) and after applying the old IAS method (Lower panel).

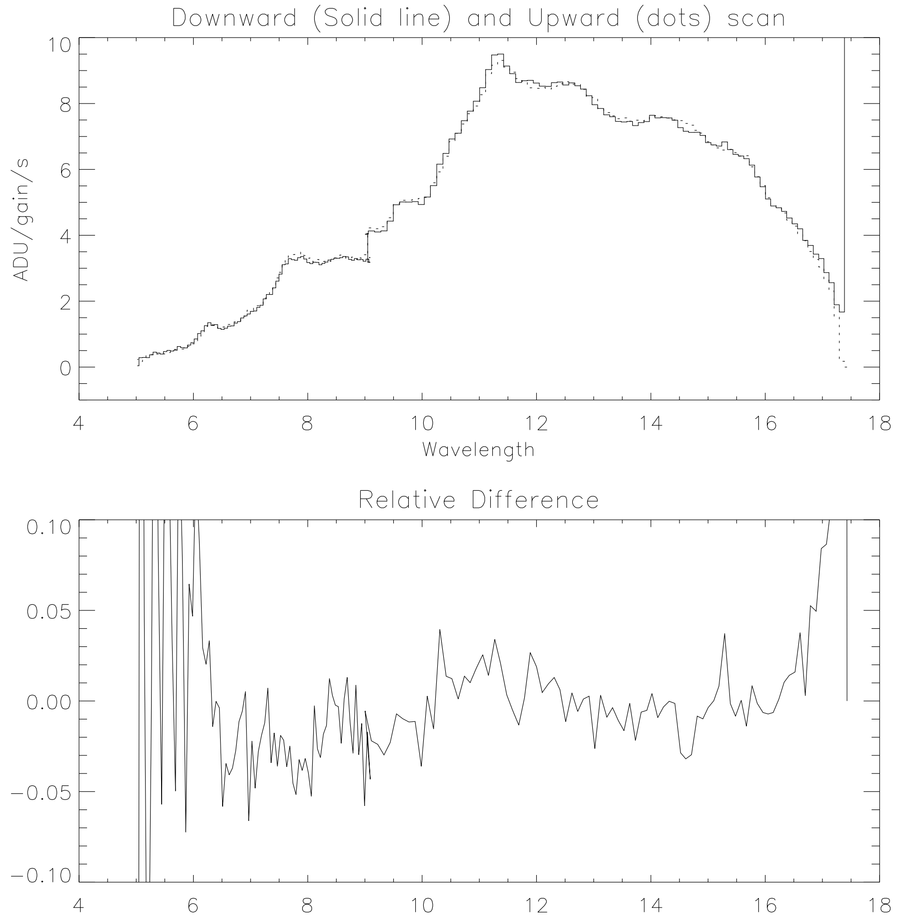

Figure 3: Upward and downward full CVF scans with the new correction (Upper panel). The lower panel shows the relative difference between the Upward and downward scan. The accuracy of the correction is a few%. The shape of the continuum of the downward scan is correct over the full spectrum.