Polarisation working group for ISO
Final Report

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Version 1.0
18 July 2001

Abstract

We summarize the observing modes, operations, data processing and data analysis for polarimetry observations with ISO. Some historical decisions which might be useful for putting the polarisation mode into the ISO perspective are mentioned. All details on data processing and instrumental calibration can be found in the proceedings of the polarisation workshop.

1 Introduction

1.1 Operational History

Two instruments on board of the Infrared Space Observatory were designed to carry out polarimetry observations. Both ISOCAM and ISOPHOT had filterweels with linear polarisers which enabled measurements of polarised light at three polarisation angles (0, 120 and 240 degrees) in a given filterband.

During the development of ISO it was already recognized that the polarisation capabilities of the observatory required a substantial amount of support and dedicated instrument expertise. The load by these modes was expected to be high in proportion to the number of scientific projects that could be envisaged.

To save resources for the other - more demanded - modes, it was decided to give polarisation a reduced support and a lower priority during the ISO mission. As a consequence, there were no automatic uplink procedures and scheduling tools for polarisation observations developed prior to launch. All operations would have to be done "manually".

1.2 Operational requirements

Polarisation degrees of more than 20% in the infrared are only expected from strong non-thermal (synchrotron) emitters (Klaas et al, 1999b). For more common sources with thermal emission in the infrared, polarisation degrees of less than 5% are expected (e.g. Alexander et al, 1999; Onaka 1999).

Polarisation observations are differential measurements, i.e. the difference signal between measurements in two polarisers divided by the mean total signal is a measure for the linear polarisation. Sources with polarisation degrees of 3% require an instrumental stability per polariser cycle of better than 1% and a S/N ratio of better than 100 on the source after background subtraction, to obtain a significant ($\geq 3\,\sigma$) detection. In this calculation we did not include additional uncertainties introduced by the subtraction of the instrumental polarisation vector.

The instrumental stability as well as the noise figures of the detectors were the most difficult parameters to quantify during the mission. Due to the limited manpower it took some time to determine the best observing strategy for both the ISOCAM and ISOPHOT polarisation modes. With the required instrumental stability and S/N, and considering the limited support from the Science Operations Centre, it was decided to carry out polarisation observations in only a few filters with mostly fixed parameters (such as measurement sequence, integration time, polariser cycles, etc) to keep the amount of free parameters as limited as possible. In addition, in the observing strategy the redundancy in data collection was maximized to minimize ambiguities. This resulted in observations which required much more observing time per pointing than initially foreseen. Observers had to revisit their programmes, which led to a significant reduction in proposed targets.

2 Description of polarisation modes

PHT polarisation was available for observers but only in two filters: P_25 and C_160. Minimum integration time was set to 256 s per polariser which gives an minimum on-target-time (OTT) of 1137 s for one PHT51 pointing. The maximum S/N which can be achieved in C_160 is about 250, but a S/N as low as 80 can also occur in the same time, therefore only targets that are brighter than the background (in the beam) can be measured with sufficient accuracy - of order 1%. Errors of better than 0.5% cannot be achieved. The P_25 mode was not commissioned in sufficient detail, and the observer's data will be used as well for calibration evaluation. The commissioning reports can be found in Klaas (1997a) and Klaas (1997b). A description of the polarisation modes which accompanied the official release can be found in [6].

At 170 μm, a redundant observation of a 2×2 minimap with one position seen by all 4 pixels was recommended to obtain a handle on possible systematic effects. For sources much brighter than the background ($F_{source}/F_{back} > 5$) a single source and background pointing should be sufficient. For weaker sources ($1 < F_{source}/F_{back} < 4$) and extended sources, the minimap is a better choice. E.g. for a single pointing 256 s per polariser and $F_{source}/F_{back} = 1$, the $1\,\sigma$ polarisation error is 4%.

CAM polarimetry was available in a single user selected narrow or broad band filter using the LW detector. Two observing procedures were available, first, the free entrance hole and the three polarisers were rotated on each raster point and, second, an entire raster was performed before a different polariser was selected. The latter procedure was recommended for extended sources on the CAM array. Both procedures could be repeated to obtain several observing cycles. A full description can be found in Siebenmorgen (1996).

3 Uplink and data handling

Uplinking and scheduling were done "manually". Routines have been developed by U. Klaas (PHOT) and R. Siebenmorgen (CAM) to facilitate the production of command sequences for uplink. Most observations with ISOPHOT were performed in fixed time mode because of the minimap observing strategy. It was not possible to use standard raster pointing mode. The coordinates of each pointing in the raster had to be calculated manually for a given observing date.

At the other end, the telemetry data formats of the polarisation observations were standard, i.e. they are identical to the telemetry data formats of any other PHT or CAM observation. The ERD part of the pipeline could process the TDF from the polarisation modes without any special adjustments. Further automatic (OLP) processing at SPD or AAD level would have required special routines and was therefore not developed.

In addition, it was felt that the polarisation data cannot be interpreted without a high level of interactive analysis. Therefore all polarisation data in the archive are only ERD level. Interactive analysis (PIA or CIA) is required for further processing and analysis.

4 Data processing and Calibration

Processing of the polarisation data and the accompanying calibration issues are discussed in detail in Klaas et al. (1999; PHT50 and PHT51), Müller et al (1999; PHT50), Laureijs & Klaas, (1999; PHT51), and Siebenmorgen (1999; CAM05).

The papers by Klaas et al (1999) and Siebenmorgen (1999) describe the data processing methods to obtain the optimum (mean) signal per polariser and the derivation of the Stokes parameters. All papers give a discussion on the instrumental polarisation, significantly present in both PHT and CAM instruments, and how the observations should be corrected for this additional polarisation component.

References

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