Astronomical Data Analysis Software and Systems VI
ASP Conference Series, Vol. 125, 1997
Gareth Hunt and H. E. Payne, eds.

The ISOPHOT Interactive Analysis PIA, a Calibration and Scientific Analysis Tool

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Abstract. ISOPHOT is one of the instruments on board the Infrared Space Observatory (*ISO*), launched in November 1995 by the European Space Agency. ISO**P**HOT **I**nteractive **A**nalysis, **PIA**, is a scientific and calibration data analysis tool for ISOPHOT data reduction. The PIA software was designed both as a tool for use by the instrument team for calibration of the PHT instrument during and after the *ISO* mission, and as an interactive tool for ISOPHOT data analysis by general observers. It has been jointly developed by the ESA Astrophysics Division (responsible for planning, direction, and execution) and scientific institutes forming the ISOPHOT consortium.

PIA is entirely based on the Interactive Data Language IDL (IDL92). All the capabilities of input/output, processing, and visualization can be reached from window menus for all the different ISOPHOT sub-systems, in all levels of data reduction from digital raw data, coming from the *ISO* telemetry, to the final level of calibrated images, spectra, and multi-filter, multi-aperture photometry. In this article, we describe the structure of the package, putting special emphasis on the internal data organization and management.

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1. Introduction

ISOPHOT (Lemke et al. 1996) is one of the four instruments on board *ISO*, the Infrared Space Observatory (Kessler et al. 1996), launched in November 1995 by the European Space Agency. As the first true space observatory for infrared astronomy, *ISO* is making the majority of its observing time available to the astronomical community.

ISOPHOT is the *ISO* instrument with the widest wavelength coverage—it is also the most complex. It contains several sub-instruments for performing photometry, polarimetry, and imaging in the infrared range of 2.5–240 μm, and low resolution spectro-photometry in the range 2.5–11.6 μm. Spacecraft raster observations and beam chopping are included in different modes.

The different ISOPHOT capabilities lead to a large number of observing modes and corresponding data products, as well as a large number of calibration files needed both for commanding the instrument (uplink), and for performing data analysis. As a consequence, the instrument calibration and general data analysis are rather complex tasks.

The general requirements, main design concepts, and development of an ISOPHOT interactive analysis system for calibration and scientific analysis are described elsewhere (Gabriel et al. 1996). In this paper, we concentrate on the specific requirements for interactive data reduction by general ISOPHOT observers, and how this is achieved within PIA.

2. ISOPHOT Data Reduction

ISOPHOT data reduction consists basically of three parts:

1. **Removal of instrumental effects.** Instrumental features are corrected using either calibration files or parametric algorithms. Calibration files were established by the ground calibration, and are partly updated in flight using PIA (Gabriel et al. 1997b). The different parameters used by the data correction algorithms are changeable and testable by dedicated menus, showing graphically and textually the results of applying a correction algorithm.

2. **Flux calibration** can be performed by using either default detector responses or calibration measurements, which run in association with almost all astronomical observations (Laureijs et al. 1996). Both possibilities are included in PIA, the second performed by analysing calibration measurements with dedicated tools for reviewing the results.

3. **Combination of data into images/spectra/photometric and polarimetric tables.** The final results of an observation can be obtained by combining data from:

   a) different raster positions, view angles, and detector pixels within a measurement to obtain images (Gabriel et al. 1997a);

   b) different pixels of the ISOPHOT spectrometer within a measurement to obtain spectra and parameterizing functions describing them; or

   c) measurements from different filters, apertures, and polarimeters to obtain photopolarimetric tables.

3. Internal Data Handling and Reduction

The scientific data corresponding to an ISOPHOT measurement is incorporated by PIA into a single entity, an IDL "structure" contained in a corresponding internal buffer. A structure is a collection of several variables of different types. The main variables are pointers to one or two-dimensional arrays.

Data reduction is organized by the various levels of processing. Every structure can be reduced to the next level, also contained in its corresponding buffer. PIA recognizes five main levels of data reduction. Any number of structures can be contained in the internal buffers, allowing access to data from different measurements/levels at any time for comparisons, correlation analysis, etc.

On every reduction level, several data corrections can be performed. PIA is capable of testing and configuring all the parameters used for those corrections, giving information on the outcome in graphical and statistical form. Several selection criteria for discarding data can be applied, which, in combination with the graphical capabilities, represent the optimal data reduction. Information about instrument configuration, observation characteristics, and reduction steps already applied to the data can be recalled from every level.

Input and output are possible in FITS format (FITS 1993), as well as in a PIA internal format, for all levels. This allows for data re-processing from any level in a later session, exporting data to other astronomical software packages, accessing and processing data from the ISOPHOT Standard Product Generation (Laureijs et al. 1996), at every level of reduction.

The graphical user interface (GUI), covering all package features, is user-friendly, easy to understand, and usable by every *ISO* observer without any knowledge of IDL, the PHT instrument, or the data structures. However, it is possible to leave the GUI, and still access all package routines and buffers interactively, at the plain IDL level. Re-entering PIA after performing data reduction in IDL is also possible, allowing PIA users to expand the package.

4. Documentation, On-line Help and Distribution

The PIA User Manual (Gabriel et al. 1996), written in hypertext format, is available via a Web browser of the user's choice from the PIA main menu. Individual chapters are linked to the corresponding graphical interfaces, to be recalled context sensitive. All the interfaces are fully described in the manual, which includes a tutorial, processing algorithm descriptions, data structure definitions, etc. A special chapter on the use of PIA structures and programs outside the GUI is also provided.

In addition, documentation for every PIA routine is given, available via the IDL on-line help system. This facility is intended to allow an "advanced" PIA user to run PIA single programs at the IDL interactive level, or to replace routines in the PIA graphical environment.

The package is freely distributed,[3] including executables, calibration files, and all documentation. It is available for platforms running IDL (from version 3.6 on), and its installation is extremely simple.

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[3]During the operational phase of *ISO* PIA is distributed by the ISOPHOT Data Center at MPIA, Heidelberg, Germany. E-mail: phthelp@orion.mpia-hd.mpg.de

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