The ISOPHOT Interactive Analysis PIA, a calibration and scientific analysis tool

C. GABRIEL[1]

European Space Agency - Astrophysics Division

J. ACOSTA-PULIDO[1]

Max-Planck Institut für Astronomie, Heidelberg, GERMANY

I. HEINRICHSEN[1], D. SKALEY[2]

Max-Planck Institut für Kernphysik, Heidelberg, GERMANY

H. MORRIS

Rutherford-Appleton Laboratory, Chilton, Didcot, UK

W.-M. TAI

Dublin Institute for Advanced Studies, Dublin, IRELAND

Abstract. ISOPHOT is one of the instruments on board the Infrared Space Observatory ISO, launched in November 1995 by the European Space Agency. The 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 the use of the instrument team for calibration of the PHT instrument during and after the ISO mission, and as an interactive tool for ISOPHOT data analysis for 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^R, (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 the different levels of data reduction. This applies, starting from digital raw data, coming from the ISO telemetry, to the final level of calibrated images, spectra, multi-filter, multi-aperture photometry. In this article we describe the structure of the package, putting special emphasis on the internal data organization and managing.

[1]Currently at the ISO Science Operations Centre, Villafranca, Apdo 50727, E-28080 Madrid,SPAIN

[2]Now at the Max-Planck Institut für Radioastronomie, Bonn, GERMANY

1. Introduction

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

ISOPHOT is the instrument with the widest wavelength coverage within the ISO mission, and also the most complex one. It contains several sub-instruments for performing photometry, polarimetry and imaging in the infrared range of [2.5-240.] microns, and low resolution spectro-photometry in the range [2.5-11.6] microns. Spacecraft raster observations as well as 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 calibration of the instrument and the general data analysis are rather complex tasks.

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

2. ISOPHOT Data Reduction

The ISOPHOT data reduction consists basically of three parts, namely:

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 updated partly in flight using PIA (Gabriel et al, 1996/b). The different parameters used by the data correction algorithms are changeable and testable by dedicated menus, showing by plot and text the results of the application of a correction algorithm.

2. Flux calibration

   This can be performed either by using default detector responses or using the outcome of calibration measurements, which run associated to almost all astronomical observations (Laureijs et al, 1996). Both possibilities are included in PIA, the last one carried out by analysing the calibration measurement using dedicated tools for accepting/varying the achieved results.

3. Combination of data into images/spectra/photometric and polarimetric tables

   The final results expected by an observation can be obtained by combination of data from:

a) different raster positions, view angles and detector pixels within a measurement, to obtain images (Gabriel et al, 1996/c); or

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

c) different measurements using different filters, apertures, 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', which is 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 according to 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. An indefinite number of structures can be contained in the internal buffers, thus giving the possibility of accessing 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. Also several selection criteria for discarding data can be applied, which in combination with the graphical capabilities represent the best way to optimize data reduction. Information about instrument configuration, observation characteristics and also reduction steps applied to the data including parameter values chosen can be recalled from every level.

Input and output are possible in FITS format (FITS90) 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), on every level of reduction.

The graphical interface, covering the full capability of the package, is user friendly, easy to understand, usable by every ISO observer without any knowledge of IDL, of the PHT instrument, or of the data structures. However, it is possible to leave the graphical I/F, having access to all the package routines and the buffers fully interactively, on the plain IDL level. Re-entering PIA after performing data reduction by these means is also possible, thus giving the possibility to the PIA users of expanding the package capabilities.

4. Documentation, on-line help and distribution

The PIA User Manual (Gabriel et al, 1996/d), written in hypertext format, is reachable by a 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 algorithms chapters, data structures definitions, etc. A special chapter on the use of PIA structures and programs outside the graphical I/F is also provided.

In addition documentation for every PIA routine is given, which can be recalled via the IDL on-line help system. This facility is intended for making possible to an "advanced" PIA user, both to run PIA single programs on the IDL interactive level or to replace routines to be incorporated within the PIA graphical environment.

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

References

FITS, 1990, "Flexible Image Transport System, Draft Standard", NASA Science Data Systems Standards Office, NSDSSO 100-0.1, NASA Goddard Space Flight Center, Greenbelt.

Gabriel,C., Acosta-Pulido,J., Heinrichsen,I., Morris,H., Skaley,D. and Tai,W.-M., 1996, "Development and capabilities of the ISOPHOT Interactive Analysis (PIA), a package for calibration and astronomical analysis", in Proceedings of the 5th International Workshop on 'Data Analysis in Astronomy', Erice, Italy, in press.

Gabriel,C., Acosta-Pulido,J., Kinkel,U., Klaas,U. and Schulz,B., 1996/b, "Calibration with the ISOPHOT Interactive Analysis (PIA)", in this volume.

Gabriel,C., Heinrichsen,I., Skaley,D. and Tai,W.-M., 1996/c, "Mapping using the ISOPHOT Interactive Analysis PIA", in this volume.

Gabriel,C., Haas,M., Heinrichsen,I. and Tai,W.-M., 1996/d, "ISOPHOT Interactive Analysis User Manual", available from ESA/ISO Science Operations Centre, VILSPA, or MPI Astronomie Heidelberg.

IDL, 1992, IDL is a registered trademark of Research Systems, Inc., copyright 1992.

Laureijs,R., Richards,P.J. and Krüger,H., 1996, "ISOPHOT Data Users Manual", V2.0, available from ESA/ISO Science Operations Centre, VILSPA.

Lemke,D., Klaas,U. et al.:1996, A&A ISO dedicated issue, in press.

Kessler,M.F., Steinz,J.A. et al.:1996, A&A ISO dedicated issue, in press.

[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