ABSTRACTS BOOK

Exploiting the ISO Data Archive

Infrared Astronomy in the Internet Age

June 24 – 27, 2002
Parador de Sigüenza, Spain

Scientific Organising Committee
J. Cernicharo (CSIC)
C. Cesarsky (ESO)
F. Genova (CDS)
T. de Graauw (SRON)
C. Gry (ESA) (chair)
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Thomas Müller
Sibylle Peschke
Alberto Salama
Bernhard Schulz
Ana Willis

CONFERENCE SCHEDULE

(as of June 17^{th}, 2002)

Sunday, June 23rd

16:00 - 20:00	*Registration and installation of posters*
20:00 - 21:00	*Welcome reception: "Vino español"*
21:00 -	*Festivities in Sigüenza*

Monday, June 24th

Session I: The ISO Data Archive - Content & Context (Chair: T. Prusti)

09:30 - 09:35	A. Salama	Introductory address
09:35 - 10:00	A. Salama	The ISO Data Archive: Overview of scientific content and use
10:00 - 10:25	M. Harwit	The success, and unexhausted potential of ISO's Central Programme
10:30 - 10:50	P. Benvenuti	The place of the ISO Data Archive in the International Virtual Observatory
10:55 - 11:25	*Coffee break*	
11:25 - 11:45	F. Genova	Archive interoperability in the Virtual Observatory
11:50 - 12:05	B. Ali	The ISO Visualizer: A new way to present ISO data
12:10 - 12:25	J. Brauher	An ISO-LWS Survey of Galaxies: An example of a systematic use of the archive from conception to results
12:30 - 12:45	All	Concluding discussion on the content and context of the IDA
13:00 - 14:30	*Lunch*	

Session II: Solar System

14:30 - 14:50	T. Fouchet	The achievements and potential of the ISO archive for planetary studies
14:55 - 15:15	T. Müller	Unexploited ISO observations of solar system objects
15:20 - 15:35	All	Concluding discussion on ISO solar system studies
15:35 - 16:05	*Coffee break*	

Session III: Astrochemistry and Solid-State Physics (Chair: R. Waters)

16:05 - 16:30	J. Cernicharo	The spectroscopy potential of the ISO data base
16:35 - 17:00	C. Joblin	What lies hidden in the ISO archive on solid-state dust features
17:05 - 17:20	F. Boulanger	The scientific potential of the CAM-CVF data base
17:25 - 17:40	K. Kraemer	An Atlas of full-grating SWS spectra: classification and processing
17:45 - 18:00	All	Concluding discussion on ISO chemistry studies

Tuesday, June 25th

Session IV: Stars and Circumstellar Matter (Chair: I. Yamamura)

09:30 - 09:55	R. Waters	Potential of the ISO archive for stellar studies

10:00 - 10:20	J. Blommaert	Status and potential of the ISOGAL project
10:25 - 10:45	B. Vandenbussche	The scientific potential of the post-helium data base
10:50 - 11:05	T. Tsuji	Warm molecular sphere of red giant and supergiant stars – Confirmation and Extension with the ISO Data Archive
11:10 - 11:40	*Coffee break*	
11:40 - 11:55	P. García-Lario	The transition from AGB stars to PNe as seen by ISO
12:00 - 12:15	R. Szczerba	Pumping of the 1612 MHz maser emission from circumstellar envelopes of OH/IR stars
12:20 - 12:40	M. Jourdain de Muizon	Debris disks around stars
12:45 - 14:15	*Lunch*	
14:15 - 14:40	B. Nisini	Star formation and early evolution in the ISO data base
14:45 - 15:00	F. Strafella	The IR continuum of the Herbig Ae/Be stars as seen by the ISO spectrometers: a contribution to the modeling of the circumstellar environment
15:05 - 15:20	T. Prusti	Luminosity functions of young stellar clusters: ISO data archive as a part of the Virtual Observatory
15:25 - 15:40	S. Molinari	A star formation/ISM astronomical database
15:45 - 16:00	All	Concluding discussion on ISO stellar studies
16:00 - 16:30	*Coffee break*	

Session V: Parallel Modes and Serendipity Surveys (Chair: D. Lemke)

16:30 - 16:45	S. Ott	Status and scientific potential of the ISOCAM parallel mode survey
16:50 - 17:05	T. Lim	The scientific potential of the LWS parallel and serendipity modes
17:10 - 17:25	M. Stickel	The scientific potential of the PHT serendipity survey
17:30 - 17:45	All	Concluding discussion on general surveys
18:00 - 20:00		Optional data processing demonstrations
21:00 - 23:00	*Conference dinner*	

Wednesday, June 26th

Session VI: Interstellar Matter (Chair: F. Boulanger)

09:30 - 09:55	P. Cox	The potential of the ISO archive for interstellar medium studies
10:00 - 10:15	A. Abergel	Evolution of very small dust particles in molecular clouds
10:20 - 10:35	M.A. Miville-Deschênes	The role of the ISOCAM archive for the study of the diffuse interstellar dust emission.
10:40 - 10:55	B. Jiang	Mid-IR interstellar extinction towards the ISOGAL field m18.63+00.35
11:00 - 11:30	*Coffee break*	

11:30 - 11:50	C. Kiss	An archive survey of cirrus structures with ISOPHOT
11:55 - 12:10	C. del Burgo	The far-infrared signature of dust in high-latitude regions
12:15 - 12:35	E. Habart	Gas to dust interaction studies in the ISO data base
12:40 - 12:55	E. Polehampton	The ISO LWS spectral survey of Sagittarius B2
13:00 - 13:15	All	Concluding discussion on ISO interstellar studies

13:15 - 14:45 *Lunch*

Session VII: Galaxies

14:45 - 15:05	G. Helou	Interstellar medium of normal galaxies
15:10 - 15:25	T. Onaka	Infrared emission spectrum of the Galaxy and external galaxies based on the IRTS and ISO archival data
15:30 - 15:45	K. Wilke	The Small Magellanic Cloud in the far infrared

16:00 - 21:00 *Visit of the cathedral and tour to Atienza*

Thursday, June 27th

Session VII: Galaxies (Cont'd) (Chair: G. Helou)

09:30 - 09:55	R. Tuffs	Normal galaxies in the FIR
10:00 - 10:15	U. Klaas	Extragalactic research with ISOPHOT pipeline products
10:20 - 10:45	D. Lutz	ISO spectroscopy of bright galactic nuclei

10:50 - 11:20 *Coffee break*

11:20 - 11:40	M. Haas	Distant dust - high redshift in the ISO archive
11:45 - 12:00	A. Verma	A mid-infrared spectroscopic atlas of starburst galaxies
12:05 - 12:15	R. Siebenmorgen	Mid-IR radiation of 3C radio galaxies: I. Observations and models
12:15 - 12:25	W. Freudling	Mid-IR radiation of 3C radio galaxies: II. Results
12:30 - 12:45	All	Concluding discussion on ISO extragalactic studies

12:45 - 14:15 *Lunch*

Session VIII: Cosmology and Deep Surveys (chair: M. Harwit)

14:15 - 14:40	H. Dole	ISO and the Cosmic Infrared Background
14:45 - 15:00	D. Fadda	A mid-infrared look of the Lockman hole
15:05 - 15:20	R. Perez Martinez	Lensing Survey - Background galaxies and foreground cluster properties
15:25 - 15:40	G. Rodighiero	A far-infrared view of the Lockman Hole from ISOPHOT
15:45 - 16:00	M. Vaccari	ELAIS data reduction with the LARI method: Final analysis of ISOCAM LW3 fields
16:05 - 16:20	All	Concluding discussion on ISO cosmological studies
16:20 - 16:35	Th. de Graauw	Conference summary
16:35		End of conference

LIST OF POSTERS
(updated June 12^{th})

Session I: The ISO Data Archive - Content & Context

J. Matagne	The Infrared Space Observatory users community
G. Pilbratt	The Herschel mission - Overview and relevance of archives
I. Yamamura	Yet another infrared archive – Release of the Infrared Telescope in Space (IRTS) Archive Data

Session III: Astrochemistry and Solid-State Physics

D. Clément	On the infrared band profiles of SiC nanoparticles - comparison with ISO-SWS spectra
I. Llamas Jansa	Laboratory in-situ infrared spectroscopy of carbon nanoparticles

Session IV: Stars and Circumstellar Matter

P. Ábrahám	Circumstellar dust around main-sequence stars: what can we learn from the ISOPHOT archive?
J. Chiar	Circumstellar carbonaceous material associated with late-type dusty WC Wolf-Rayet stars
O. Krause	Follow-Up studies of very young intermediate and high mass star forming regions detected by the ISOPHOT Serendipity Survey
D. Lorenzetti	The complete far infrared spectroscopic survey of Herbig AeBe stars obtained by ISO-LWS
T. Posch	Features of oxide dust particles in circumstellar shells of AGB stars
A. Ramdani	Low mass loss in late type stars
R. Szczerba	ISO spectra of proto-planetary nebulae and [WR] planetary nebulae
I. Yamamura	The extended atmosphere and evolution of the RV Tau star, R Scuti

Session VI: Interstellar Matter

J.P. Baluteau	Galactic plane $[CII]$ and $[OI]$ lines diffuse emission
J. Goicoechea	LWS Fabry–Perot spectrum of Sgr B2
Y. Okada	ISO spectroscopy of Sharpless 171
P. Persi	An infrared study of the Chameleon II and III
C. Vastel	[CII] 157.7 μm line in absorption towards the galactic centre: connection with bright IR galaxies

Session VII: Galaxies

C. Bot	Multi-wavelengths analysis of dust emission from the Small Magellanic Cloud
A. Contursi	Investigating the $[CII]$–PAHs relation with a large ($\sim$150) sample of local galaxies
M. Haas	What powers the PAH emission in galaxies?
O. Krause	ISOPHOT's Serendipity Survey discovers an unusually cold ultraluminous infrared galaxy
M. Stickel	The complex far-infrared morphology of M86
P. Temi	Infrared emission from elliptical galaxies: The case of NGC4649,

	NGC4472, and NGC4636
P. Väisänen	A flux calibration of ISOCAM ELAIS catalogues and infrared colours of star-forming galaxies in ELAIS fields
A. Verma	ISO Photometry of hyperluminous infrared galaxies: Implications for the origin of their extreme luminosities

Session VIII: Cosmology and Deep Surveys

P. Héraudeau	The European Large Area ISO Survey: $90\mu m$ number counts

Session IX: New Developments in Data Reduction

R. Blomme	The memory effect of the ISOPHOT-C100 detector
A. Coulais	Accurate physical model for direct modeling of point source transients for ISOCAM LW detector
C. del Burgo	Improved calibration strategy for faint objects
B. Fouks	Frequently Asked Questions about the transient correction of ISOCAM data Perspectives for SIRTF and ASTRO-F
C. Lari	The LARI method for ISOCAM and ISOPHOT data reduction and analysis
A. Moor	A full scale photometric investigation of the ISOPHOT minimap mode
P. Richards	Development of the ISOPHOT pipeline during the Active Archive Phase
B. Schulz	P32Tools: Reduction of ISOPHOT P32 oversampled maps
R. Tuffs	Photometric mapping with ISOPHOT using the "P32" Astronomical Observation Template

Session I:

THE ISO DATA ARCHIVE - CONTENT & CONTEXT

The ISO Data Archive: Overview of scientific content and use

A. Salama

ISO Data Centre, Science Operations and Data Systems Division, Research and Scientific Support Department of ESA, Villafranca del Castillo, P.O. Box 50727, E-28080 Madrid, Spain

ESA's Infrared Space Observatory (ISO) was the first infrared observatory in space. About 30,000 scientific observations (150,000 if one considers parallel and serendipity mode observations) were made during its 28 month mission (1995-1998), in the 2-240 um wavelength range, with a variety of spectral and spatial resolutions. Targets include a wide range of astronomical objects, from within the Solar System out to the most distant galaxies. Most of these observations will remain unique for decades, making the ISO Data Archive a treasure trove for further astronomical research. Over 800 ISO articles have been published in the refereed literature since late 1996.

The ISO Data Archive (IDA), developed by the ISO Data Centre of the European Space Agency (ESA) has been online since December 1998. Through its innovative and powerful JAVA user interface, the general astronomer or the instrument expert can make complex queries on the ISO product observations catalog and ancillary data, then have a quick textual and visual look at the data before retrieving the observations with a wide variety of options. The ISO Archive contains about 420 GB of data. About 4 GB of relevant parameters have been extracted from the data products and ingested as metadata in a database. In the past years, preparing for the Virtual Observatories, development has been focussed to improve the IDA interoperability with other astronomical archives, via accessing other relevant archives or via providing direct access to the ISO data for external services. The IDA interface is now also easily configurable, thus allowing its use for other archives, such as XMM-NEWTON Science Archive.

An overview will be given of the ISO Data Archive in the framework of the ISO Active Archive Phase. This will cover usage, functionality and contents. Relevant inventories will be given of the ISO observations per science topic and per observing mode, and their relation with the publication statistics.

INVITED TALK

The *ISO Central Programme's* Unexplored Potential

Martin Harwit[1,2]

[1] *511 H street, SW, Washington, DC 20024-2725, USA*
[2] *also Cornell University*

The *ISO Central Programme* covered a broad range of topics, ranging from planetary to stellar and interstellar investigations and the exploration of extragalactic sources and the cosmos. This contribution concentrates on the five main classes of investigations into which the *Central Programme* was divided – Solar System studies, stellar and interstellar observations, and extragalactic and cosmological surveys – and highlights several major accomplishments. The focus then shifts to portions of the *Central Programme's* accomplishmnets that promise to provide further astronomical insight as the archives compiled in the course of the mission are probed in greater depths.

INVITED TALK

The place of the ISO data Archive in the International Virtual Observatory

P. Benvenuti[1]

[1] *Space Telescope European Coordinating Facility,*
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Germany

The Astrophysical Virtual Observatory (AVO) Project is a Phase-A, three year study for the design and implementation of a virtual observatory for European astronomy. A virtual observatory (VO) is a collection of interoperating data archives and software tools which utilize the internet to form a scientific research environment in which astronomical research programs can be conducted. In much the same way as a real observatory consists of telescopes, each with a collection of unique astronomical instruments, the VO consists of a collection of data centres each with unique collections of astronomical data, software systems and processing capabilities.

The AVO aims at becoming more than a simple, albeit nice to have, efficient federation of multi-mission archives: by an intelligent use of meta-data concepts and of emerging paradigms in the utilization of internet resources (GRID), it will provide unique research capabilities not currently available for the full exploitation of the existing archives.

The AVO Phase A project involve six partner organisations among which ESA and is co-funded by the European Commission. The AVO project was preceded by a smaller scale programme named ASTROVIRTEL, also funded by the EC, which is now entering its third year of operation.

The talk will describe the main goals of the AVO project and will discuss in particular the role that the ISO data Archive may have in the AVO context. The specific modifications to the metadata descriptors that may be needed to achieve an efficient interoperability and the advantages of the adoption of the GRID paradigm will also be addressed.

INVITED TALK

Archive interoperability in the Virtual Observatory

F. Genova[1]

[1] *CDS, Observatoire de Strasbourg, UMR 7550, 11 rue de l'Université, 67000 Strasbourg, France*

Main goals of the Virtual Observatory projects are to build interoperability between astronomical on-line services, observatory archives, data-bases and results published in journals, and to develop tools permitting the best scientific usage from the very large data sets stored in observatory archives and produced by large surveys. The different Virtual Observatory projects collaborate to define common exchange standards, which are the key for a truly International Virtual Observatory, and for instance the first common milestone is a standard allowing exchange of tabular data, called VOTable. The Interoperability Work Area of the European *Astrophysical Virtual Observatory* project aims at networking European archives, in order to build a prototype using the CDS VizieR and Aladin tools, and to define basic rules to help archive providers in interoperability implementation. This prototype is readily available for scientific usage, to get user feedback (and science results!) at an early stage of the project. The ISO archive is a very active participant in this endeavour, and in information networking. The on-going inclusion of the ISO log in SIMBAD will allow to build further high level services for users.

The ISO Visualizer: A new way to present ISO data

Babar Ali[1], Alberto Salama[2], Mihseh Kong[1]

[1]*IPAC/Caltech, Pasadena, CA*
[2]*ISO Data Center, Madrid, Spain*

The ISO Visualizer is a new web-based tool with the following aims:

- to provides, by means of an allsky map, an overview of all ISO observations.
- to visualize the ISO observation coverage of a specified spatial region.
- to provide the relevant observing parameters and access to the original proposal abstracts.
- to provide URL link to ESA's ISO postcard server.

In this contribution, I will demonstrate these functionalities, provide the latest access statistics and the plans for future development of the ISO Visulizer and its merger with other online services.

INVITED TALK

An ISO-LWS Survey of Galaxies: An Example of the Systematic use of the ISO Data Archive from Conception to Results

James R. Brauher[1]

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United States

The Internet Age has revolutioned the way in which astronomers carry out research by enabling the use of publicly-available data stored in database archives. The Infrared Space Observatory (ISO) Data Archive (IDA) grew out of the need of astronomers worldwide to access the data obtained by ISO. Although many scientific papers have resulted from ISO data, the IDA still contains a vast amount of untapped scientific potential.

I demonstrate the systematic use of the ISO Data Archive and describe its role in building a catalog of far-infrared fine structure lines for 227 galaxies whose data will be available from the IDA. This example provides an insight into the many opportunities the IDA offers, and I detail the process of this project from its inception to its current results. The results from this archival research are consistent with other ISO studies and add new information to the understanding of the ISM of galaxies. Many new projects can be spawned through the use of this publicly-available, fully-reduced dataset that forms a foundation for observations with future observatories (SIRTF, SOPHIA, Herschel).

The Infrared Space Observatory Users Community

J. Matagne[1]

[1] *ISO Data Centre, Apartado 50727, 28080 Madrid, Spain*

We will present an overview of the Infrared Space Observatory world-wide users community and give a brief outline of the main services provided. The ISO Data Archive (IDA) users community has continued to expand apace since the public opening of the archive in December 1998 and is currently composed of 1250 registered users.

- From its creation, the ISO Help Desk (helpdesk@iso.vilspa.esa.es) -the first line support for the ISO community- received and answered a bit less than 30.000 e-mails.
- The ISO Data Centre based in Madrid, Spain, welcomed and supported more than 135 visitors over the past 4 years and organised several workshops and conferences (including this one).
- The ISO World Wide Web service (http://www.iso.vilspa.esa.es/), has been growing quickly and serves every week more than 3000 HTML pages, 6000 images and 2000 documents to 4000 distinct hosts.

A snapshot of the IDA users registration rate and distribution per country, the ISO Data Centre visitor flow and the ISO WWW server access statistics will be given. The figures will be compared to other astronomical archives and facilities.

POSTER

The Herschel Mission - Overview and Relevance of Archives

Göran L. Pilbratt

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The Herschel Space Observatory (formerly known as FIRST) is the fourth cornerstone mission in the European Space Agency (ESA) science programme. It will perform imaging photometry and spectroscopy in the far infrared and submillimetre part of the spectrum, covering approximately the 57−670 μm range.

The key science objectives emphasize current questions connected to the formation of galaxies and stars, however, having unique capabilities in several ways, Herschel will be a facility available to the entire astronomical community.

Herschel will carry a 3.5 metre diameter passively cooled telescope. The science payload complement – two cameras/medium resolution spectrometers (PACS and SPIRE) and a very high resolution heterodyne spectrometer (HIFI) – will be housed in a superfluid helium cryostat. The ground segment will be jointly developed by the ESA, the three instrument teams, and NASA/IPAC.

Herschel will be placed in a transfer trajectory towards its operational orbit around the Earth-Sun L2 point by an Ariane 5 (shared with the ESA cosmic background mapping mission Planck) in early 2007. Once operational Herschel will offer a minimum of 3 years of routine observations; roughly 2/3 of the available observing time is open to the general astronomical community through a standard competitive proposal procedure.

I intend to report on the current implementation status of the various elements that together make up the Herschel mission, and to introduce the mission from the perspective of the prospective user of this major facility. I will also want to discuss the relevance of archives to Herschel and its archive.

Yet Another Infrared Archive
— Release of the Infrared Telescope in Space (IRTS) Archive Data —

I. Yamamura[1], M. Tanaka[1], H. Takahashi[2], S. Makiuti[1], T. Hirao[3], T. Ootsubo[4], M. Matsuura[5], K. Okumura, D. Ishihara[4], T. Nakagawa[1], H. Murakami[1], T. Onaka[4], and H. Shibai[3]

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[2] *National Astronomical Observatory, Oosawa, Mitaka, Tokyo, 181-8588, Japan*
[3] *Department of Physics, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8602, Japan*
[4] *Department of Astronomy, University of Tokyo, Hongo 7-3-1, Tokyo, 113-0033, Japan*
[5] *Department of Physics, UMIST, P.O.Box 88, Manchester M60 1QD, UK*

We are pleased to announce that the IRTS data archive is now open to public. IRTS is the first Japanese space infrared mission. The 15 cm diameter telescope with four focal-plane instruments was on board the Space Flyer Unit-1 (SFU-1). The satellite was launched by the Japanese H-II rocket March 1995 (about a half year before ISO!). IRTS surveyed about 7% of the whole sky in two stripes during its 26 day mission, in the wavelength ranges from 1.4 μm to 700 μm. After seven-year intensive data reduction, the first set of catalogues and image maps are now available for public use. We below briefly describe the instruments and released products.

The Near-Infrared Spectrometer (NIRS):
The NIRS carried out spectral-photometry survey in the wavelength ranges of 1.4–2.5 and 2.9–4.0 μm with the resolution of $\Delta\lambda \sim 0.1$ μm. The point source catalogue containing approximately 14000 stars is in archive.

The Mid-Infrared Spectrometer (MIRS):
The MIRS observed the sky in 4.5–11.7 μm with 32 channel detectors. The spectral resolution was ~ 0.23 μm. About 600 sources with relatively good quality spectra are included in the point source catalogue.

The Far-Infrared Line Mapper (FILM):
The FILM observed in four channels at [OI]63 μm, [CII]158 μm, 155, and 160 μm (continuum). The intensity of [CII] 158 μm line was extracted from the 155, 158, and 160 μm channels. Image maps and scan data of 155 μm continuum and [CII]158 μm intensity are released this time.

Far-Infrared Photometer (FIRP):
The FIRP is equipped the bolometer system and surveyed in four wavelength bands (150, 250, 400, and 700 μm). The good quality image maps (mainly of the 250 μm band) are released.

More catalogues/image maps are being processed and will be added to the archive in near future. The data are distributed by the ISAS's space science data archive system*DARTS* (http://www.darts.isas.ac.jp/). Also they will be available through *IPAC*.

Session II:

SOLAR SYSTEM

The achievements and potential of the ISO archive for planetary studies

Thierry Fouchet

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All the planets and their satellites outwards of Mars have been observed by the Short Wavelength Spectrometer (SWS) and the Long Wavelength Spectrometer (LWS) aboard the ISO satellite. Together, these two spectrometers covered the range 2.3- to 180-μm, which had never been entirely observed before. (For example the Infrared Interferometric Spectrometer (IRIS) aboard the Voyager mission only operated from 5- to 50-μm). The two ISO spectrometers also sharply increased the spectral resolution compared to most of the previously available data in the same spectral range. (Voyager/IRIS was limited to $R \sim 200$ while ISO/SWS achieved between $R \sim 1\,500$ for grating observations and $R \sim 30\,000$ for Fabry-Pérot observations.) The ISO Photo-Polarimter (ISOPHOT) and the ISO Camera (ISOCAM) also observed some planets of our Solar System.

These observations have granted planetary scientists with a wealth of new findings. Water was detected in the four giant planets stratospheres as well as in Saturn's satellite, Titan. This provided evidence for an external source of oxygen in the outer Solar System. Micrometeorites, planetary rings or cometary impacts are possible sources. ISO improved our determination of the D/H ratio in the four giant planets, through the first detection of rotational lines of HD. The D/H ratio in the giant planets is a major parameter in Solar System formation models, but also in chemical evolution models for our own Galaxy. ISO also detected many new hydrocarbon molecules and a radical, providing new clues on methane photochemistry in the jovian planets.

However, most of these results have been achieved with the SWS instrument alone. This means that a great potential of new findings still remains inside LWS, ISOPHOT and ISOCAM data.

The LWS spectral range also encompasses HD and H_2O rotational lines. As the H_2O lines present in the LWS-range do not have the same intensities as the lines present in the SWS-range, we could retrieve some information on the vertical distribution of water, hence some constraints on the pressure level where water is deposited in giant planets stratosphere. This, in turn, could provide some informations on the water external source, dust vs cometeray impacts, or the dust entry velocity. The combination of SWS and LWS HD lines would also be valuable. It could give a more accurate determination for the D/H ratio in H_2, to be use in a comparison with the D/H ratio measured in CH_3D. Indeed, the D/H ratios in methane and molecular hydrogen are fractionated by an exchange reaction strongly coupled with dynamics in the giant planets interiors. A more accurate D/H ratio measurement in H_2, would hence provide some insights into giant planets dynamics. Moreover, many known molecules (NH_3, PH_3), and unknown but potential species (HF, ...) present rotational lines in the 50–180-μm range. New molecules could then be detected in the future from LWS spectra.

Even some part of the SWS spectral range are still unexploited. Indeed, in a paradoxical way, planetary scientists have been biased in their analysis towards well known spectral regions, observable from the ground. For this reason, the 5–7 μm window (obscured by water lines in the terrestrial atmosphere) still awaits a thorough analysis. It could be fruitful to understand the thickness, the altitude location and the composition of clouds in the giant planets. In this purpose, it would be especially valuable to combine the analysis of SWS spectra with the analysis of ISOCAM images. Indeed, ISOCAM obtained images of Mars, Jupiter, Saturn and Neptune at its highest spatial resolution (1.5 arcsec). None of these images has been published nor even analysed. If ISOCAM images cannot compete with interplanetary missions in terms of high spatial resolution, they nevertheless provide a uniform coverage of planetary disks that is not always achieved by dedicated planetary missions. ISOCAM data could thus provides some new insights on the overall cloud cover for the giant planets.

INVITED TALK

Unexploited ISO Observations of Solar System Objects

Thomas G. Müller[1]

[1] *Max-Planck-Institut für extraterrestrische Physik Giessenbachstrasse, 85748 Garching, Germany*

The solar system programme of ISO comprised about 6 % of the total ISO science time (only 1.4 % in terms of number of observations). The programme included dedicated observations of 40 asteroids, 16 comets, 6 planets, and 8 planetary satellites. In addition, programmes were conducted on zodiacal light, comet tails and trails, solar system dust, planetary satellites, planetary rings, zodiacal bands, and the Earth's circumsolar dust ring. In serendipitous and parallel observations many more asteroids and comets were seen by chance, some of which were not even discovered at the time of the observations.

Among the highlights of ISO were revelations about the nature of cosmic dust in various environments, including investigations of dust in our own solar system and its connection to old stars and protoplanetary disks. In this context, two comets (Hale-Bopp and Hartley 2) were thoroughly studied and had their chemical compositions, the natures of their silicates, and their degrees of crystallisation determined. The large ISO database of spectroscopic observations of comets (including tails and trails) and of interplanetary dust will allow more studies in this new field of "astro-mineralogy" in the future.

ISO performed direct measurements of the ro-vibrational water lines of the brightest comets, which yielded the rotational temperature of water, its ortho-para ratio, and the corresponding spin temperature. With recent reduction techniques, one could think of extending the results to fainter comets and of drawing a more precise picture of objects originating from the Edgeworth-Kuiper belt and the Oort cloud.

Large samples of photometric comet observations remain to be analysed and interpreteted in terms of coma modeling, dust production rates, and grain size distributions. Here again, only the most prominent objects appear in the literature. But the difficulty of extended source photometry on structured backgrounds is a major obstacle and will prevent the achievment of all proposed scientific goals.

The topic of "astro-mineralogy" is also important for asteroids: Thermal infrared spectroscopy allows us to establish the connections between meteorites and asteroids. The effects of space weathering and aqueous alteration of surface materials can be studied, and a better understanding of the commonalities of asteroid near-IR taxonomy and mid-IR spectroscopy may be possible. Now that different laboratory studies of meteorites and mineral mixtures have become available, the work of analysing spectra has started, and promises exciting results in the future. But many of the key observations are still hidden in the ISO data archive.

The thermal emission measurements of asteroids in combination with visible lightcurve studies provide the means of analysing size, shape, and albedo properties through radiometric techniques. Thermal properties of individual asteroids and their surface regolith can be derived through an advanced thermophysical model which has been developed in close contact with the ISO data. This model is also the basis for the photometric interpretation of many dedicated and serendipitous observations of asteroids at wavelengths between 2 and 200 μm.

I will try to give an overview of the as yet unexploited ISO observations of solar system objects and what can be expected in the future. Emphasis will be put on different aspects of "astro-mineralogy" in relation to comets and asteroids. A second focus will be those solar system targets which were seen by chance in the ISOPHOT serendipity survey, in the ISOCAM parallel survey, and in other large survey programmes. All properties of planets, rings, and planetary satellites are covered by a talk on "The achievements and potential of the ISO archive for planetary studies".

Session III:

ASTROCHEMISTRY AND SOLID-STATE PHYSICS

INVITED TALK

The spectroscopy potential of the ISO data base

J. Cernicharo

INVITED TALK

What lies hidden in the ISO archive on solid-state dust features?

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The four instruments on board ISO (the camera CAM, the short- and long-wavelength spectrometers SWS and LWS, and the photometer PHOT) were particularly well suited to rekindle our interest in interstellar dust. Several years after the mission ended, we can surely talk about the ISO revolution for solid state matter whether this refers to carbonaceous dust, silicates and more generally oxides, or molecular ices. Thanks to a continuous and broad spectral coverage, new features have been and are still being discovered which reveal new chemical structures and are a real mine of information for the astrochemistry and more recent astromineralogy fields. Furthermore, dust features appear now, thanks to ISO, as a powerful tool to quantify the evolutionary stage of astronomical objects.

This paper describes how a full, thoughtful and organised exploitation of the ISO data archive could provide us with a comprehensive view of the dust cycle in the interstellar medium from its formation sites, through its processing and likely replenishment in the interstellar medium, and to its destruction sites. Such a view is necessary to gain more insights into the chemical, physical and dynamical conditions that govern the evolution of astronomical objects. Such a study should be performed in close connection with laboratory simulations and modelling studies as was already nicely exemplified in a few specific cases.

The scientific potential of the CAM-CVF data base

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The ISOCAM CVF observations provide spectroscopic and imaging information on the mid-IR emission from matter in space for a wide range of objects and physical conditions. We will summarize the performances achieved with this observing mode in terms of sensitivity and dynamic range and show that for extended emission it will not be superseded by the IRS spectrometer on SIRTF. We will also illustrate with scientific results the potential of this data base for the studies of small dust grains.

INVITED TALK

An Atlas of 2.4–45.2 μm Spectra from ISO: Classification and Processing

K.E. Kraemer, S.D. Price, G.C. Sloan, H.J. Walker, & R.F. Shipman

The Infrared Space Observatory (ISO) took almost 1250 2.4–45.2 μm spectra of over 900 celestial objects with the Short Wavelength Spectrometer. Based on these data, we have developed a comprehensive system of infrared spectral classification. The primary discriminant between classes is the temperature of the dominant emitter, e.g., a hot stellar photosphere or a cold dust cloud. Subgroups are made up of objects with similar spectral features, such as silicate absorption or atomic fine-structure lines. We have also created an atlas of uniformly processed spectra from the data. Starting from the most processed form available from the ISO Data Archive, which consists of 288 spectral segments per observation, we have reduced and combined these data into single, continuous spectra. The classifications, atlas, and processing software have been submitted for publication in the Astrophysical Journal Supplement and will also be available to the general astronomical community upon request.

On the infrared band profiles of SiC nanoparticles - comparison with ISO-SWS spectra

D. Clément, H. Mutschke, I. Llamas Jansa, Th. Henning

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We present new results of laboratory infrared spectroscopy of SiC nanoparticles. We studied the influences of (1) the state of agglomeration, (2) the incorporation of nitrogen atoms, and (3) the surrounding medium on the profile of the infrared phonon band at about 11 μm. We find that the band profile corresponds well to the one observed in the infrared spectra of carbon stars, if isolated grains of the cubic SiC modification are measured in an environment of low refractive index. We compare our laboratory spectra to ISO-SWS spectra of a sample of carbon stars showing the 11 μm band in emission or absorption. The background correction for this band has been improved by considering the absorption due to acetylene and HCN at wavelengths longward of the SiC emission band (Aoki et al. 1999).

Agglomeration of the grains, incorporation into other media, or doping with nitrogen can change the appearance of the bands dramatically. According to an analytical correction basing on the optical constants of cubic SiC (Papoular et al. 1998), the influence of the surrounding medium is smaller than the other effects. Agglomeration causes a strong shift of the band maximum by about 1 μm to larger wavelengths. The interaction of the lattice vibrations with charge carriers introduced by nitrogen impurities can produce a shift to shorter wavelengths.

These effects may account for the observed variations in the profile of this band whereas the crystal type of the SiC particles should not strongly influence the band profile (see also Mutschke et al. 1999). Nitrogen impurities, additionally, cause a strong continuum absorption at near infrared wavelengths which would be very important for the energy balance of such grains in circumstellar regions.

References:

Aoki W., Tsuji T., Ohnaka K. 1999, A&A 350, 945
Mutschke H., Andersen A.C., Clément D., Henning Th., Peiter G. 1999, A&A, 345, 187
Papoular R., Cauchetier M., Begin S., Le Caer G. 1998, A&A 329, 1035

POSTER

Laboratory in-situ infrared spectroscopy of carbon nanoparticles

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Because amorphous carbon grains are considered among the main components of cosmic dust, the characterization in the laboratory of their physical and chemical properties is needed to interpret the data obtained by the astronomical observations. We have analysed the 4000-1000 cm^{-1} (2.5-10μm) region of the spectrum of material produced in the laboratory by laser pyrolysis of acetylene, which serves as analog to the interstellar material. The obtained spectra can be compared to ISO spectroscopic data.

IR spectra of hydrogenated carbon grains as a function of the condensation parameters are presented. Analysis of the spectra related to the profile and subpeak positions of the 2940 cm^{-1} (3.4 μm) aliphatic CH stretching-mode band and its relation with the CH deformation modes near 1470 cm^{-1} (6.8 μm) and 1370 cm^{-1} (7.25 μm), the carbonyl band near 1700 cm^{-1} (5.9 μm), and the aromatic C=C vibration band at 1620 cm^{-1} (6.2 μm) is presented.

Particular care is placed to eliminate possible systematic errors in the interpretation of the results introduced by contamination of the samples. Especially, we aimed in avoiding oxidation by contact with the laboratory atmosphere. This was possible by extracting the particles from the condensation zone into a beam in high-vacuum environment and collecting them on a KBr substrate for in-situ infrared measurements.

The results are compared with previous experimental data (e.g. Schnaiter et al. 1999) and with the infrared spectral characteristics of diffuse interstellar medium carbonaceous dust, which has been proposed in the literature to be predominantly hydrocarbon in nature (aromatic and aliphatic forms), with a low content of nitrogen or oxygen (Pendleton & Allamandola 2002).

References:

Pendleton Y.J., Allamandola L.J. 2002, ApJSS 138, 75

Schnaiter M., Henning Th., Mutschke H., et al. 1999, ApJ 519, 687

Session IV:

STARS AND CIRCUMSTELLAR MATTER

Potential of the ISO archive for stellar studies

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The ISO archive contains a remarkably rich harvest of observations of stellar and circumstellar phenomena. It is the combined studies of individual objects and larger samples that have become possible with the opening of the ISO archive to the astronomical community, and that lead to new insights into the structure and evolution of stars.

This talk will focus on studies of stellar photospheres and winds throughout the HR diagram.

In the case of hot stars, the ISO archive is useful to characterize the nature of the circumstellar gas using only the IR part of the spectrum: this can then be applied to stars with high optical extinction, where only the IR spectrum is accessible.

Many cool stars have been observed with ISO, and the use of the archive has shown to be particularly important in recognizing the structure of asymptotic giant branch stars and the composition of their winds.

INVITED TALK

Status and potential of the ISOGAL project

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The ISOGAL project provides a survey of the inner disk and bulge of the Galaxy. It combines 7 and 15 μm ISOCAM observations with DENIS I,J,K_s data. In total about 16 square degrees were observed down to a sensitivity of 10-20 mJy in the mid-infrared, detecting $\approx 10^5$ sources, mostly AGB stars, red giants and young stars.

The main features of the ISOGAL survey and observations will be presented, together with a discussion of the data processing and quality. ISOGAL has produced 7 and 15 μm raster images and a five wavelengths point source catalogue.

An overview of the main scientific results will be given: observations of infrared dark clouds, the infrared extinction law, analysis of stellar populations, red giants and AGB stars, AGB circumstellar dust and mass-loss, Young Stellar Objects.

The scientific potential of the post-helium data base

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After the depletion of the liquid Helium used for the cooling of the telescope and the focal plane instruments of ISO, the temperature of the focal plane remained sufficiently low to operate the InSb band 1 detectors of the SWS. Observing time was granted to a programme aimed at extending the MK-classification to the near-infrared. Good quality spectra (2.36μm – 4.1μm) of 238 stars at moderate resolution ($\lambda/\delta\ \lambda \approx$ 1500 – 2000) were obtained in the time slots available during the satellite engineering test programme. We will show how these data have been calibrated, and give a detailed calibration error budget.

Low scheduling priority was given to the programme stars that were already observed at a similar resolution during the nominal part of the mission in the framework of various other programmes. The dataset has been completed with these 55 nominal-phase spectra. The resulting data-set, the ISO-SWS post-helium atlas of near-infrared stellar spectra, contains 293 spectra covering a large range of spectral types and luminosity classes. The calibrated and reduced data is now available electronically for applications in classification and stellar population synthesis. We will illustrate such applications with two examples:

First we will discuss how the post-helium database has been used to derive empirical methods to constrain the spectral type, luminosity class, mass-loss rate and the geometry of the ionized circumstellar material of early-type stars from line strengths between 2.3 and 4 μm.

We will also show the results of an automatic, unsupervised bayesian classification of the post-helium spectra. We will show that especially for late-type stars the class according to this unbiased classication constrains spectral type, luminosity class and fundamental stellar parameters. We will propose a number of applications of the same bayesian classification software for large datamining projects on all ISO spectral data.

ORAL PRESENTATION

Warm Molecular Sphere of Red Giant and Supergiant Stars - Confirmation and Extension with the ISO Data Archive

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A possible presence of the warm molecular sphere (hereafter be referred to as MOLsphere for simplicity) around red (super)giants was proposed based on the early observations with the ISO SWS[1]. However, such a proposition of the new component may have been deemed as *ad hoc* probably because there was no theory to have predicted such a new component. Nevertheless, we recently found convincing evidence for the presence of the warm MOLsphere with the use of the ISO Data Archive. First, the water 6.3 μm bands was identified on the high resolution SWS spectra ($R \approx 1600$) in the K giant Aldebaran (K5III) as well as in several early M giant stars (M0III - M3.5III), which are too hot for water to be formed in their photospheres[2]. Second, the water 6.3 μm bands was also found in the early M supergiant α Ori (M2Iab) as absorption and in μ Cep (M2Ia) as distinct emission[3]. This finding of water in emission clearly indicates that the water exists in the extended outer atmosphere of μ Cep and not, for example, in the "starspot" in the photosphere. Also, the excitation temperatures of the water bands in the K and early M (super)giants are found to be rather high ($T_{\rm ex} \gtrsim 1500$K). Thus, the warm MOLsphere, distinct from the photosphere, hot chromosphere, and cool wind, should be a general feature of late-type (super)giant stars including early M (even including K giant).

Now, the problem is to clarify the nature of the MOLsphere in more details. For this purpose, we extend the survey of the water 6.3 μ bands, which may be the best indicator of water because of the little blending with other molecular bands, to a larger sample of the lower resolution SWS spectra ($R \approx 200$) from the ISO Data Archive. It appears that the water 6.3 μ bands present in all the M giants but they are not necessarily well correlating with the M subtypes. Also, the water bands are well observed in the late M giants, but the nature of water in this case is more obscure, since the late M giants may be cool enough for water to be formed in their photospheres. Then, one problem in late M giant stars is how to separate the contributions from the photosphere and the MOLsphere. For this purpose, we examined the photospheric structure in detail and show that a larger part of the observed water bands in the non-Mira late M giants should be originating in the MOLsphere rather than in the photosphere.

As a possible origin of the MOLsphere, we assume a large turbulence in the upper photosphere and found it possible to generate a photosphere with a very large extension. However, the extended part of such a model is rather rarefied and the problem is how to supply matter to the extended region. Such a difficulty may be shared with the origin of the stellar chromosphere as well as of the mass-loss outflow in the red giants prior to the the AGB phase (*i.e.* non-pulsating phase). Although stellar photosphere ($0 \lesssim \tau < \tau_0$ where $\tau_0 \approx 10 - 100$ in most model photospheres) could be modeled rather easily, we have no self-consistent model of the outer atmosphere ($-\infty < \tau \lesssim 0$) including MOLsphere, chromosphere and wind. What is important is that ISO opened a possibility of the new picture of the stellar atmosphere ($-\infty < \tau < \tau_0$) by establishing the presence of a new component – the MOLsphere, and there should still be new clues to be extracted from the extensive ISO Data Archive for our explorations of the atmospheric structure (not necessarily restricted to the photosphere!) of various kinds of red giant and supergiant stars.

[1] Tsuji,T., Ohnaka, K., Aoki, W., & Yamamura, I. 1997, A&A,320, L1
[2] Tsuji,T. 2001, A&A, 376, L1
[3] Tsuji,T. 2000, ApJ, 540, L99

The transition from AGB stars to PNe as seen by ISO.

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We present a classification scheme for stars evolving in the transition phase between the Asymptotic Giant Branch (AGB) to the Planetary Nebula (PN) stage based on the detailed analysis of low resolution infrared SWS spectra from 2 to 45 μm of a large sample of stars available in the Infrared Space Observatory (ISO) Data Archive. The classification is made on the basis of the detection and analysis of: i) gas phase features in the extended atmospheres of the AGB stars; ii) solid state features in the neutral circumstellar shells surrounding the transition objects; and iii) nebular emission lines in the ionized PNe. This information, combined with the observed overall infrared energy distribution, is used to determine the evolutionary stage of each of the sources in the sample. The results here presented provide a complete view of the spectroscopic evolution expected in this short transition phase as a function of the mass of the progenitor star as the starting point for future spectroscopic research on this field in the infrared range.

ORAL PRESENTATION

Pumping of the 1612 MHz maser emission from circumstellar envelopes of OH/IR stars.

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The population inversions which lead to the OH maser emission from circumstellar envelopes of cool stars have long been thought to be radiatively pumped (Shklovsky, 1996: Astron.Tsirk., No.372; Elitzur et al. 1996: ApJ, 205, 384). However, the OH rotational lines involved in this pumping scheme lie in the far-infrared and became observable only with the ISO spectrometers. The first detection of the 34.6 μm absorption line of OH, which is thought to pump the well known 1612 MHz OH maser emission, has been reported by Justtanont et al. (1996: A&A, 315, L217) in the ISO-SWS01 spectrum of NML Cyg. Subsequently, Sylvester et al. (1997: MNRAS, 291, L42) discussed the ISO SWS02 spectrum of IRC+10420 which shows the 34.6 μm doublet structure and its LWS spectrum with the ensuing rotational cascade lines.

With the aim to investigate the pumping mechanism of the 1612 MHz OH maser line in more details we have searched the ISO Data Archive for available SWS and/or LWS observations for about 1000 OH/IR stars for which IRAS LRS spectra are available (Chen et al. 2001: A&A, 368, 1006). Among 79 OH/IR sources which have ISO SWS data we found 14 objects with clear and 11 with tentative 34.6 μm absorption line. We present the physical properties of these sources and discuss maser pumping efficiency and the importance of collisional effects in the pumping of the 1612 MHz maser emission.

Debris discs around stars

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A total of about 410 hours of ISO observing time was devoted to the study of discs around pre-main-sequence, main-sequence and evolved stars. Some proposals addressed the problem of the occurrence of such discs in large homegeneous samples or in star clusters while others studied already known discs around specific stars. This represents a total of 2188 ISO observations (in 37 different proposals), of which 1147 have now appeared in some 33 refereed publications. There are still 169 hours of ISO observing time to be investigated on the subject, mainly ISOPHOT and ISO-SWS observations.

In this review I shall present the main results obtained with ISO on the occurrence, lifetime and evolution of pre-planetary discs, as well as chemical composition of the dust. A significant number of new discs have been discovered since IRAS thanks to the wider wavelength range of ISO over IRAS, its sophisticated photometric instrument and its spectroscopic capabilities. These have allowed much more detailed studies. We now have a rather accurate idea of the occurrence of discs around main-sequence stars, their lifetime, size and dust temperature. The brightest discs (β Pic, several Herbig Ae/Be stars, 51 Oph) have been observed spectroscopically and various dust features have been identified such as amorphous and crystalline silicates, PAHs, thus leading to a better understanding of the dust processing in those discs.

I will also inventory what is still left in the ISO archive and ready to be exploited. I will try to identify which aspects of the topic can be addressed with this large set of remaining ISO data.

INVITED TALK

Star formation and early evolution in the ISO data base

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Since new born stars are cold and heavily extincted, the spectral range from mid to far infrared is the most suited to investigate over the different phases of the star formation process. In this respect, ISO has given a fundamental step towards enlarging the observational scenario for understanding the still poorly known field of the formation of a new star. The importance of the ISO mission in this field is testified by the large fraction of observations performed towards star forming regions during the mission lifetime. ISO has gathered observations over all the evolutionary phases which brings from a cold pre-stellar core to a well formed star in pre-main sequence phase.

In this contribution I will summarize the observations available in the ISO Data Archive concerning the different phases of the star formation process. I will then try to focalize the attention on possible projects to be performed with these data addressing specific issues of the young star evolution which remain still uncovered. As an example of a large project exploiting the ISO Data Archive I will finally show the results of a far infrared spectroscopic survey performed on a sample of 54 Young Stellar Objects in different evolutionary phases, from the youngest protostars to pre-main sequence stars. Such a study have allowed to define average spectroscopical properties of different classes of YSOs, which will be useful for the definition of programmes for future space missions.

The IR continuum of the Herbig Ae/Be stars as seen by the ISO spectrometers: a contribution to the modeling of the circumstellar environment.

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We present a study of the whole sample of the Herbig Ae/Be (HAeBe) stars observed with the spectrometers (SWS+LWS) on board of the Infrared Space Observatory (ISO). These objects have been studied not only by considering their IR continuum emission but also taking into account all the available photometric data, collected from the optical region to the radio wavelengths. In this way their global spectral energy distributions (SEDs) have been compared with the results of the radiative transfer calculations in the context of a model for the circumstellar environment. Besides different density laws and dust types, this model considers also the possibility for the presence of:

1) different radial density distributions describing respectively the inner and outer regions of the envelope;

2) polar cavities that could be evacuated by the action of the stellar wind associated with the pre-main sequence phases.

We present the result of a selection for the best models which has been done by considering both the spectral fit to the observed SEDs and the consistency between the model parameters and the corresponding observable quantities as the spectral type, the distance and the extinction. A possible relationship is noted between the geometry of the CS matter distribution and the evolutive stage of the HAeBe stars. Finally the spatial appearance in the FIR of some of the selected models is discussed in connection with the ESA-Herschel Space Observatory mission.

ORAL PRESENTATION

Luminosity Functions of Young Stellar Clusters: ISO Data Archive as a Part of the Virtual Observatory

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We shall introduce the ASTROVIRTEL project, Luminosity Functions of Young Stellar Clusters, with special emphasis on the reasons to do the work under the virtual observatory concept. The possibilites to obtain the input data from 1) literature, 2) survey type data (e.g. IRAS catalogues or POSS images), and 3) observatory type data (e.g. ISO or ESO archive) are evaluated. In the context of the meeting the focus will be set to ISO: What would need to be available in the ISO data archive so that it would be a useful part of the virtual observatory specifically for the luminosity function question? These requirements will be compared with the facilities and data available in the ISO archive. As a case study, the quality of Chamaeleon I data in the ISO archive is assessed in view of the potential of the still unanalysed ISO data of other young stellar clusters.

A Star Formation/ISM Astronomical Database

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As in all areas of modern science, the ongoing development of new technologies in the optical, infrared, millimeter and submillimeter astronomy from the ground as well as from space, has resulted in an explosion of digital data relating to the interstellar medium in general and star formation in particular. These data are suitable for ingestion into archives and for sharing over computer networks; in fact, the volume of data is now such that it has become impossible to use effectively by non-digital means. What this massive body of data currently lacks is a logical and efficient "directory"; services which not only capture the knowledge of the existence of data but provide the added value of efficient search and interrelationship mechanisms.

The Star Formation/ISM Database will be a set of on-line services adding value to existing data archives and published journals, along the lines of the very successful NASA/IPAC Extragalactic Database (NED) and SIMBAD projects but with a focus on star formation an the interstellar medium (ISM) within the Milky Way. Unlike NED and SIMBAD, however, the Star Formation/ISM Database must deal with multi-wavelength measurements of *extended regions* and cross-correlative relationships between disparate measurements. It is expected that the main uses of the Star Formation/ISM Database will be observation planning and multi-wavelength, large area, cross-correlation studies.

POSTER

Circumstellar dust around main-sequence stars: what can we learn from the ISOPHOT archive?

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The discovery of circumstellar dust around main-sequence stars, the Vega-phenomenon, was one of the main results of the IRAS mission. The deeper understanding of this phenomenon was also a main goal for ISOPHOT. In several key projects hundreds of normal stars were observed at far-infrared wavelengths; these data are available now in the ISO Archive.

The results of the observations are summarized in several papers published by the separate groups involved in the key projects. These groups, however, used different data reduction methods and calibration files, and – in spite of their somewhat contradictory final conclusions – no attempt has been done so far for a critical comparison of their results.

In this contribution we analyse all normal star observations from the Archive performed with ISOPHOT in minimap mode, the highest quality observing mode of ISOPHOT. The data were reduced and calibrated in a homogeneous way including several extra steps in addition to the OLP 10 scheme (see Moór et al., this conference). For each star we determined flux density, sky background level and sky background fluctuation, and compared the flux distribution over the minimap with the footprint of a true point source. On the basis of the large homogeneous data base we check which fraction of the stars harbour disks; whether the results of the separate groups are consistent concerning the temporal evolution of the dust disks; and if there are indications in the data for the existence of very faint disks similar to the Kuiper Belt of our Solar System.

Circumstellar Carbonaceous Material Associated with Late-Type Dusty WC Wolf-Rayet Stars

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We have used data from ISO's Short Wavelength Spectrometer to study the 5–10 μm spectral region of five WC-type Wolf-Rayet stars with dense dust shells. Wolf-Rayet stars represent one of the final stages of stellar evolution for massive stars. They are thought to follow an evolutionary sequence divided into three phases WN – WC – WO, corresponding to the prevalence of different emission lines in their spectra. In the WN phase, hydrogen is consumed in the CNO cycle. Extensive mass loss takes place in the WC stage; products of helium burning are mixed to the surface, enhancing the carbon and further depleting the hydrogen abundance. Late-type WC stars are now known to be surrounded by heated circumstellar dust, although the process by which this dust forms and survives in the harsh WC-star environment is not known.

We have discovered that an absorption feature at 6.2 μm observed in some WC-star spectra is carried by circumstellar amorphous carbon dust. The central wavelength corresponds to the carbon-carbon stretching vibration in amorphous carbon material. We show that the absorption feature cannot be carried by the interstellar dust along the line of sight. Since the circumstellar visual extinction toward these objects is minimal ($\sim$ 1 mag.), these dust grains have to be rather large ($\sim$ 1 μm) and point towards dense clumps as the sites of dust formation. One of the WC stars in our study shows emission features in the 6–10 μm region, which are suggestive of emission from aromatic materials in the circumstellar environment, perhaps residing in a circumstellar disk.

These results have implications for dust nucleation in the hostile environment around WC-type Wolf Rayet stars, a topic which has only recently been theoretically explored. A key question which follows from our observations of carbonaceous dust in the WC star circumstellar environment is why precursor carbon-structures — chains, polycyclic aromatic rings, fullerenes — are not observed.

POSTER

Follow-Up studies of very young intermediate and high mass star forming regions detected by the ISOPHOT Serendipity Survey

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We report results from our search for very young intermediate and high mass star forming regions based on their thermal dust emission detected by the 170 μm ISOPHOT Serendipity Survey. A total sky coverage of 15 % makes this survey of the ISO satellite the largest one ever performed in the unexplored FIR beyond the IRAS 100 micron band. It is particularly sensitive to cold dust condensations with a dust temperature below 20 K. The cold and luminous FIR emitters of our sample were identified by a cross-correlation of cold sources in the ISOSS database coinciding with embedded proto-stellar objects detected by the 2MASS and MSX infrared surveys. The low temperature and large mass of the cold circumstellar matter in these objects, which has not yet been dispersed, indicates a recent begin of star formation.

In order to explore the early evolutionary stage of these objects, we have initiated follow-up campaigns at (sub)mm (SCUBA,MAMBO), infrared (MAX,UFTI,TIMMI2) and optical wavelengths. While ISOPHOT allowed us to measure the peak of thermal dust emission, the combination with ground based mm-continuum measurements of high spatial resolution is essential for investigating the morphology of the dust component. Molecular line data of the associated molecular cores (^{12}CO and ^{13}CO) have been used for kinematical distance estimates and gas masses of the star forming complexes. Optical and infrared observations were performed in order to classify the embedded (proto)stellar sources. Our approach of multi wavelength characterization is demonstrated in detail for the newly discovered object ISOSS J 20298+3559. The observations revealed the presence of a young and massive cluster with a total mass of 500 $M_\odot$ and an average dust temperature as low as 18 K. Several massive cold cores without infrared counterparts have been found in coexistence with a luminous Herbig B2 star, which is the most evolved object in that complex. Spectroscopic signatures for ongoing mass infall towards the Herbig star give further evidence for the young age of the system.

The complete far infrared spectroscopic survey of Herbig AeBe stars obtained by ISO-LWS.

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The ISO-LWS archive has been systematically searched in order to obtain a complete far IR spectrophotometric survey of Herbig AeBe (HAeBe) stars. This led to a final catalogue grouping about 25 % of all the known HAeBe, which complements our original list of 11 sources with 15 newly analysed objects. This catalogue constitues an essential data-base in view of the forthcoming far IR space missions (e.g. HSO), whose scientific programs are now in the planning phase. The new sources are analysed following the same approach as in our previous papers and both differences and similarities are discussed in a coherent framework. The [OI] 63 μm and the [CII] 158 μm lines are observed in many of the investigated sources, while the [OI] 145 μm remains often undetected, due to its relative faintness. Molecular lines, in form of CO high-J rotational transitions are detected in only three cases and appear associated to local density peaks. A new class of ISO-LWS spectra of HAEBE emerges, constitued by objects without any gas feature either in emission or in absorption. Not unexpectedly, these HAeBe's are those isolated from molecular clouds and, as such, they lack of the cold circumstellar material probed by far IR ionic and molecular transitions. By comparing line intensity ratios with model predictions we find that photodissociation caused by the stellar photons in a clumpy medium is likely the prevalent excitation mechanism responsible for the excitation of the far IR lines. Finally, an evolutionary trend is found according to which the contribution of the far IR line emission to the total emitted energy is less and less important with the lifetime of these objects.

POSTER

Features of oxide dust particles in circumstellar shells of AGB stars

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According to observations with ISO-SWS, oxygen-rich AGB stars with low mass-loss rates tend to exhibit rather weak silicate emission features around 10 and 18μm. However, these stars do show some interesting, comparatively narrow emission bands which can be attributed to minute solid oxide particles. One of these bands – the 13μm feature – has already been detected in IRAS-LRS spectra. It turned out, however, that the carrier of this single feature can not be identified unambiguosly, since various oxides can account for it. Among these potential carriers is α-Al_2O_3, $MgAl_2O_4$ and TiO_2 (see, e. g., Posch et al. 1999).

A recent analysis of ISO-SWS data (Fabian et al. 2001, Kerschbaum et al. 2000) has lead us to the discovery that the 13μm feature occurs together with two additional emission bands observable in the spectra of oxygen-rich dust shells at wavelegths of 16.8 and 32μm. All these bands can be assigned to resonance vibrations of $MgAl_2O_4$ (spinel) particles.

The present talk aims at presenting additional evidence for this identification. On the one hand, results of laboratory spectroscopy will be presented in order to prove that various substances – among them all known TiO_2 modifications – can emit rather efficiently in the 12–15μm range. This will also be illustrated by new results of experiments on vapour-condensed oxide nanoparticles. On the other hand, data from the ISO archive will be used to show that the coexistence of the 16.8 and 32μm bands with the 13μm band is compatible only with the hypothesis that $MgAl_2O_4$ is the carrier of these features.

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Low mass loss in late type stars

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The spectra of 83 giant stars obtained by the ISO/SWS covering the wavelenght range 2.4 - 45 μm have been analysed. The stars of our sample have been selected on the basis of their IRAS colors as low mass loss candidates ([12]-[25] $<$ 0 and [25]-[60] $<$ -1.8, where [12]-[25] = 2.5log($\frac{F_{25\mu m}}{F_{12\mu m}}$) and [25]-[60] = 2.5log($\frac{F_{60\mu m}}{F_{25\mu m}}$)). The sample includes 9 supergiants, 30 miras, 27 semiregulars, 5 irregulars and 12 IRAS objects of different types, all these stars are surrounded by oxygen-rich dust shells characterized by silicate emission.

The spectra are analysed in terms of a spherical radiative transfer model based on the DUSTY code. The model fits to the SED restricted to the ISO/SWS wavelenght range allow us to evaluate reasonably well the optical depth at 10 μm, especially since the present study is a differential analysis of the mass-loss versus variability properties for stars with small mass-loss rates. In addition, taking into account the spectral type of the star, the presence of 10 and 18 μm silicate emission features constrains drastically the other model fit parameters. The optical depth at 10 μm spans the range 0.01 to 1.8 for all the stars of our sample, with the upper limit corresponding in fact to the value where in average the 10 μm dust feature shows in self absorption and translates to a mass loss rate around $10^{-7}M_{\odot}y^{-1}$ for an optically visible mira whose luminosity equals $10^{4}L_{\odot}$. The optical depth distribution peaks abruptly around 0.05 both for miras and semiregulars, whereas supergiants are apparently more uniformly distributed in the full range. Almost all our stars have HIPPARCOS derived distances so an accurate determination of mass loss rates will be made.

The ISO/SWS spectra are compared to their equivalent IRAS/LRS in order to account for variability of the SED in the near and mid-infrared and to check for long-term changes of the circumstellar material surrounding these stars.

POSTER

ISO Spectra of Proto-Planetary Nebulae and [WR] Planetary Nebulae.

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Proto-planetary nebulae (PPNe, called also post–Asymptotic Giant Branch, or post-AGB objects) are short lasting phase (of order of 1000 yr) of stellar evolution from AGB to Planetary Nebulae (PNe). Recently, we have created a database of PPNe candidates which contains about 230 objects (Szczerba et al. 2001, in "Post-AGB objects as a phase of stellar evolution", ASSL 265, p.13). The ISO Data Archive has been searched for SWS 01 and LWS 01 spectra of PPNe candidates from our database. About 70 sources have been found with SWS 01 and about 30 with LWS 01 spectra. Spectra of good quality have been classified according to their chemical characteristics (C- and/or O-based dust and/or molecular features). The aim is to describe these two chemical paths of stellar evolution and to search for objects with mixed chemistry which could be precursors of planetary nebulae with Wolf-Rayet [WR] central stars (some of [WR] PNe show clear signatures of mixed chemistry). We have analysed ISO SWS 01 spectra for 16 [WR] PNe and found that Policyclic Aromatic Hydrocarbon (PAH) molecular bands (which are present in most of the observed [WR] planetaries) are more frequent than crystalline silicate features.

The extended atmosphere and evolution of the RV Tau star, R Scuti

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The analysis of ISO spectra of AGB and post-AGB stars provides unique understanding of their atmosphere and circumstellar, and their evolutionary status.

We here present results of the analysis of ISO/SWS spectra of the RV Tau star R Scuti. The data were obtained via the ISO data archive, and processed with OLP 10.1 and OSIA ver.2.0. The infrared spectra of this star are dominated by H_2O emission bands. We also identify CO, SiO and CO_2 bands. The excitation temperatures of the molecular bands are estimated as 800 K (CO_2), 1200 and 2200 K (H_2O), and 4000 K (CO), which indicate that these bands originate from an extended atmosphere, an atmosphere above the photosphere. The extended atmosphere of R Sct should be formed from matter which gradually have lifted up from the photosphere through the pulsations of the star.

In contrast to the abundant molecules around the star, the silicate dust feature is weak and the dust mass-loss rate is only $M_{\rm d} = 10^{-11}$ $M_\odot$ yr^{-1}. This implies that there might be a process to inhibit dust formation from molecules. RV Tau stars are commonly considered as post-AGB stars. While a detached dust envelope around R Sct is consistent with such an interpretation, we show that its period evolution is slower than expected. We argue that R Sct may be a thermal-pulsing AGB star, observed in a helium-burning phase.

Session V:

PARALLEL MODES AND SERENDIPITY SURVEYS

Status and scientific potential of the ISOCAM parallel mode survey

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During most of ESA's ISO mission, the mid-infrared camera ISOCAM continued to observe the sky mainly around 6.7μm with a pixel field of view of 6″ in its so-called "parallel mode" while another instrument was prime.

This permitted an unbiased survey of limited areas of the infrared sky, albeit with varying depth and wavelength per field due to the different instrumental configurations used and the highly variable time spent per pointed observation.

Dedicated calibration, data reduction and source extraction methods were developed to analyse these serendipitously recorded data: 37000 individual pointings, taken during 6700 hours of observation. Using sophisticated merging algorithms, over 42 square degrees of the sky — roughly one per mille of the celestial sphere — could be processed and catalogued.

For the final catalogue, around 30000 distinct point sources are expected. Their mid-infrared flux goes down to 0.5 mJy, with a median of 2.7 mJy for sources outside the galactic plane, and 6.3 mJy for sources inside the galactic plane.

We will give an overview of the results of this recently finished data processing effort, present the first multi-wavelength cross-correlations and outline the scientific potential of this data-set.

We expect to release the ISOCAM Parallel Point Source Catalogue and all calibrated ISOCAM parallel images to the general community this autumn, and hope this will become an attractive and valuable resource for all mid-infrared research activities and a major legacy from the ISO mission.

INVITED TALK

The scientific potential of the LWS parallel and serendipity modes

E. Caux

The Scientific Potential of the ISOPHOT 170μm Serendipity Sky Survey

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For the first time, the slewing time between pointed observations has been utilized with ISO as an integral part of a space observatory mission. Dedicated strip scanning measurements of the sky were carried out with ISOPHOT at 170μm. During ISO's lifetime, the ISOPHOT Serendipity Survey collected more than 12000 slew measurements during nearly 550 hours with a total slew length exceeding 150000 degrees, corresponding to an sky coverage of about 15%. This represents the only large scale sky survey in the unexplored wavelength region beyond the IRAS 100μm limit to date.

The slew data structure consists of very narrow stripes across the sky. Emphasis has been put on the detection of compact sources, which required the development of special algorithms. The selection and identification of objects require a multi-wavelengths approach, since cirrus confusion is a severe problem at 170 micron. Other large-scale far- and near-infrared data from the IRAS, MSX, and 2MASS surveys, and the DSS II in conjunction with optical, radio and x-ray information available in the NED and SIMBAD databases were used for the selection of well-defined samples of galaxies and cold galactic objects. The resulting source lists are used for the statistical investigation of their FIR properties, as well as the search for rare and unusual galactic and extra-galactic sources is possible.

Initially, dedicated 170μm mapping observations of a few compact sources crossed by slews were used to put the measured Serendipity fluxes on an absolute scale. The covered flux range has now been significantly extended by including all crossed asteroids and will be further consolidated using all compact Serendipity sources with 170μm maps in the complete ISOPHOT archive.

The first list of compact sources associated with galaxies have already been published, and a second much larger catalogue is in an advanced state of preparation. Investigations of cold compact galactic structures are underway. Both areas are complemented by ground-based follow-up observations of small samples of selected sources. Eventually, the source lists will be incorporated and available from databases such as Simbad and NED.

Session VI:

INTERSTELLAR MATTER

The potential of the ISO archive for interstellar medium studies

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This review will present the potential use of the ISO spectroscopic and imaging Archive data to probe the physical and chemical conditions of the InterStellar Medium (ISM). The results published so far have underscored the importance of ISO to provide insights in key areas including: the study of dense clouds from which stars form, the interaction of the gas and dust, the properties and the life cycle of interstellar dust, the metallicity gradient across the Galactic disk or measurements of water vapour in star forming regions. However, the ISO results so far described represent only a small fraction of the Archive and there are potentially many more important results relevant to the study of the ISM.

Based on the available statistics, I will try to outline potential avenues of future research and use of the ISO Archive in ISM studies. I will give a few examples which examplify the simultaneous use of the instruments on board ISO: the study of large star-forming/molecular cloud complexes, the unique availability of complete spectral scans from 2 to 196 μm to study the chemical and physical properties of regions covering a wide range of conditions, and the evolution of dust from diffuse to dense cores. Based on these examples, I will underline the importance of the ISO Archive for future space missions operating at infrared and submillimeter wavelengths (SIRTF & Herschel) as well as its use for follow-up observations at (sub)millimiter wavelengths from the ground (in particular, with interferometers).

ORAL PRESENTATION

Evolution of very small dust particles in molecular clouds

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Conducted in two broad-band filters (5-8.5 and 12-18 μm), the ISOCAM mapping of molecular clouds is a goldmine to study at small angular resolution (3-6 arcsec) the properties of the very small dust particles and the structure of molecular clouds, in relation with the local properties as well as the large scale environment. Due to the large spatial coverage and high sensitivity, the broad-band observations complement ideally spectroscopic observations to study the evolution of the emitting properties and the relative abundance of the very small particles.

We will review results obtained so far in nearby molecular clouds from ISOCAM observations, which have evidenced systematic evolutions of the small interstellar grains from shielded molecular material to photo-dissociated and photo-ionised matters. The ISO archive contains a lot of observations of molecular clouds which still have to be analysed. In a next future, these observations will be combined to observations taken at longer wavelengths by future satellites (SIRTF, ASTRO-F, Herschel,...). A full spectral coverage of the dust spectrum will allow the analysis of the physical processes acting on the different components of the interstellar dust.

The role of the ISOCAM archive for the study of the diffuse interstellar dust emission.

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The observation of diverse regions of the Interstellar Medium (ISM) is a key aspect for the study of dust evolution and its relation with the ISM small scale structure and physical conditions. More than 40 square degrees of the Galactic ISM have been observed by ISOCAM between 4 and 18 μm using several broad-band filters. These observations, combined with spectroscopic observations, allow to study spatial variations of the interstellar aromatic bands emission and the underlying continuum. They cover a wide range of brightness from bright regions of the Galactic plane down to faint infrared cirrus.

Even with its relatively small sky coverage, the ISM observations available in the ISOCAM archive will be of great use in the future for the understanding of interstellar dust evolution, which needs a complete coverage of its emission spectrum and especially of the mid-infrared range where spectral features are abundant. With its selection of broad-band filters and its spectro-imagery mode, ISOCAM will remain unsurpassed in that wavelength range and will be an important complement to SIRTF, Herschel and Planck for the study of the life cycle of dust.

To illustrate what ISOCAM brings to the understanding of dust evolution I will present the results of the analysis of high Galactic latitude fields. The observation of such diffuse, optically thin and uniformely enlightened regions gives direct measurements of the small dust grain emissivity, independantly of any modelling. Therefore, these observations, combined with observations of the gas phase, give important constrains on the dust abundance, its evolution in diffuse clouds and the link with the gas kinematics. Apart from its interest for interstellar dust evolution, the analysis of the interstellar mid-infrared emission in diffuse clouds participates also to the understanding of extra-galactic foregrounds emission which is an important issue for ongoing and future missions. This is a domain where the ISOCAM observations of diffuse emission will clearly play an important role in the future.

ORAL PRESENTATION

Mid-IR interstellar extinction towards the ISOGAL field m18.63+00.35

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A $0.35^\circ \times 0.29^\circ$ field centered at $l = -18.63, b = 0.35$ was observed during the ISOGAL survey by ISOCAM imaging at 7 and 15μm. 649 objects were detected and their brightness are measured. By combining with the DENIS data in the near-infrared J and Ks bands, we derived the extinction law at 7μm and 15μm through the relations between the color indexes J–Ks and Ks–[7] or Ks–[15]. The extinction structure along the line of sight is then determined from the values of J–Ks or Ks–[7] of the ISOGAL sources identified as RGB or early AGB stars with little mass-loss, and is compared with that derived from the radio CO and HI observation at this direction. The distribution of A_V ranges from 0 to $\sim$45 and it reflects the concentration of the extinction in the spiral arms.

An archive survey of cirrus structures

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ISO observations opened a new window to the studies of the infrared cirrus, providing measurements superseding IRAS in wavelength coverage, spatial resolution, number of photometric bands and spectroscopic capabilities. Although ISO was not dedicated for survey mode, many large areas were investigated and imaged, especially using the ISOCAM and ISOPHOT–C instruments. These measurements provide a great possibility to study the phyisical parameters, dust composition and spatial structure of the far-infrared cirrus emission in the Galaxy under various conditions.

Recently at Konkoly Observatory we settled a new database of ISOPHOT measurement from the Archive, which is dedicated for cirrus studies. Using this database a global estimate of the far-infrared sky confusion noise has been made by separating the contribution of the cirrus confusion noise from the fluctuations of the Cosmic Far-Infrared Background. The same database provided a good basis for the investigation of the small-scale spatial structure of the cirrus emission, using Fourier power spectrum techniques. These results are essential for the correct determination of the cirrus emission remained in the faintest fields of the far-infrared sky, where the Extragalactic Background can be determined.

Ongoing works in other institutions use extended maps and scans to study the possible variation of cirrus colours and grain properties and to unravel the nature of sources, which were only seen by the 100 μm filter of the IRAS satellite.

In future studies the ISO data should be supplemented by the extinction and reddening data using all-sky extinction maps and/or near-infrared surveys like 2MASS, and also by sub-mm measurements from balloon experiments (PRONAOS). These works can help in the preparation of the future far-infrared and sub-mm missions (Herschel and Planck).

ORAL PRESENTATION

The far-infrared signature of dust in high-latitude regions

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We present ISOPHOT observations in the 60-200 microns wavelength range of a sample of high latitude dust regions. Most of the selected regions are quiescent and have central column densities ranging from almost diffuse Av 0.4 to dense Av 6. FIR colors are determined for the regions. A well-defined and unique 150-200 microns emission relationship, similar to that one of the diffuse interstellar medium is followed by all the regions. This implies that in the line-of-sights analysed the far-infrared emission of the classical big grains – determined by their temperatures and grain properties – is a unique function of the dust column density. On the other hand the relative emission of the smaller dust particles, radiating mainly at $\lambda \leq 100\mu$m, shows significant variations with respect to the radiation of the big grains from region to region. These variations probably cannot be accounted completely by temperature changes and the results may indicate variations in the relative abundance of smaller grains.

Gas to dust interaction studies in the ISO data base

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Several processes couple dust to the chemical and thermodynamical evolution of the interstellar gas. The ISO data allows us for the first time to conduct a detailed study of this interplay over a wide range of gas density and radiation field strength. The confrontation between ISO observations of gas and dust emission and predictions of photo-dominated regions model allows us to constrain important processes such as the photoelectric effect on dust grains, which dominates the gas heat budget (Habart et al., 2001a), or the formation of H_2 on grain surfaces, which controls the gas chemistry (Habart et al., 2001b). I will in particular investigate the question of the H_2 formation process (by which mechanisms? On which kind of grains?), studying the dependance of H_2 formation efficiency with interstellar physical parameters (radiation field, density, temperature of gas and grains) and the respective behaviour of the H_2 emission with those of different grain populations.

ORAL PRESENTATION

The ISO LWS Spectral Survey of Sagittarius B2

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The Giant Molecular Cloud complex, Sagittarius B2, was observed in many separate observations with the ISO Long Wavelength Spectrometer. The high resolution Fabry-Pérot mode, L03, was used to undertake a full and unbiased spectral survey over the wavelength range 47–198 μm as part of the Guaranteed Time program. In addition to this, many narrow Fabry-Pérot scans (L04) were carried out at specific wavelengths and several medium resolution grating measurements (L01) were undertaken with various different pointings. These provide an extensive dataset in the archive for this important bright source.

The large dataset of Fabry-Pérot measurements has been used to investigate and improve calibration procedures and files for the LWS L03 mode. During each Fabry-Pérot observation, the instrument settings were optimised for a single detector only (the 'prime' detector). Using improved calibration procedures, data from the other nine LWS detectors can now also be calibrated and used to improve the signal to noise and reliability of prime data.

These new data have allowed us to search for faint lines in the dataset and examine line shapes with much higher signal to noise. Results from this program so far include the modelling of atomic fine structure lines towards the source, observation of faint emission in the HD ground state line leading to an estimate of the deuterium abundance, and observation of OH lines containing the three stable isotopes of oxygen.

Galactic plane [CII] and [OI] lines diffuse emission

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ISO/LWS observations (in the L01 mode) of "source-free" lines of sight in the galactic plane has been extracted from the ISO Data Archive. Two subsamples, one for the inner regions close to the Galactic Centre and the other for galactic longitudes greater than 15 degrees, were selected. In both subsample the diffuse [CII] 158um and [OI] 63 and 145um lines are compared to the FIR continuum emission. The global trends of their correlations and the different behaviour of the two subsamples are presented and the results are discussed in the light of predictions by standard models of galactic photodissociation regions.

POSTER

LWS Fabry–Perot Spectrum of Sgr B2

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In this contribution we present a detailed study of the far–IR spectrum of Sagittarius B2 molecular cloud with a spectral resolution of ∼35 Km s^{-1}. This cloud represents an interesting burst of massive star formation in the Galactic Center and may be representative of other active galactic nuclei.

The **∼50–190 μm Line Survey** includes almost all the ISO LWS/FP data base observations taken in the direction of the Sgr B2 M condensation using LWS03 and LWS04 observing modes.

The Sgr B2 spectrum is characterized by forbidden emission lines of atoms and ions of the PDRs and HII regions of the complex and by molecular features in absorption against the continuum emission of dust and located in the outer molecular envelope and in the foreground gas along the line of sight.

Molecular features includes several **rotational lines** of Oxygen–bearing species such as H_2O, $H_2{}^{18}O$, OH, ^{18}OH, and H_3O^+; Nitrogen-bearing molecules such as NH, NH_2, and NH_3; and other diatomic species such as HF or CH. Low energy **bending modes** of non–polar carbon chain radicals such as C_3 have been also observed. C_4 have been tentatively detected only in LWS01 observing mode. Atomic and ionic features include **fine structure lines** of O^0, O^{++}, C^+ and both N^+ and N^{++} only in the gratings.

Extended emission/absorption of some of these species have been observed in the 9'×27' (∼25×70 pc) raster maps of the region at much lower resolution (∼1000 Km s^{-1}). Different pipeline products have been processed and compared from 1998 to 2002 (OLP 7.01 to OLP 10.1).

ISO spectroscopy of Sharpless 171

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We report the results of one-dimensional raster scan observations of Sharpless 171 (S171) with LWS, SWS, and PHT-S on-board ISO. S171 is the main cloud associated with the Cepheus OB4 stellar association (Yang & Fukui 1992), and is an active star-forming region of typical HII-molecular cloud complex. The main heating and ionizing source of this region is believed to be the star cluster, Be 59. The observations were made at 24 positions, starting from the neighbor of Be 59 to the molecular cloud region with the spacing of $50''$. The observed area includes the ionized region, molecular region, and transision region between them. We have detected 7 forbidden lines, [OIII] 52 μm, [NIII] 57 μm, [OI] 63 μm, [OIII] 88 μm, [NII] 122 μm, [OI] 146 μm, and [CII] 158 μm, and the far-infrared continuum with LWS, [SiII] 35 μm and H_2 9.66 μm with SWS, and H_2 9.66 μm and 6.9 μm with PHT-S. Based on the observed intensities of these lines and continuum emission, we have classified the observed region into three phases and derived the physical properties of each phase, such as temperature, density, and elemental abundance.

For highly ionized regions, we have estimated the electron density from the [OIII] lines as $n_e < 150$ cm^{-3}. We have also obtained N^{++}/O^{++} abundance of $0.22^{+0.14}_{-0.07}$ assuming 57 μm and 52 μm line emissions come from the same region.

For neutral gas, the observed line and continuum intensities are in agreement with photodissociation region (PDR) model predictions (Kaufman et al. 1999) in most observed positions except for the molecular region. We have derived the gas density $n \sim 300$–1000 cm^{-3}, and the temperature $T \sim 200$–350 K at most positions. In the molecular region, [OI] 146 μm emission is very strong, and the [OI] 63 μm to 146 μm ratio is too small (~ 5) to be accounted for by PDR models. Even considering the effect of UV pumping, we could not explain this small ratio. We conclude that the absorption by oxygen atoms in foreground cool clouds is the most likely explanation. We have used the PDR model to estimate the fraction of the [CII] 158 μm emission from the ionized region at each position, which increases from 0% to 40% or more with the distance from Be 59. The line ratio of H_2 suggests that the temperature of H_2 gas is less than 1300 K.

For diffuse ionized gas, [SiII] 35 μm is found to be quite strong and the observed [SiII] 35 μm to [NII] 122 μm ratio indicates the silicon abundance in the diffuse ionized gas to be at least about 30% of solar abundance. This value is larger than the value of typical interstellar diffuse clouds (~ 5% of solar), suggesting the dust destruction in the ionized region.

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POSTER

An infrared study of the Chamaeleon II and III dark clouds

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The dark clouds Chamaeleon II and III are part of the southern hemisphere molecular cloud complex Chamaeleon. Given its proximity to the sun (D=140-180 pc) and high galactic latitude, this complex is one of the best place to study low-mass star formation. From CO observations results that the three main dark clouds Cha I, II and III have different characteristics, suggesting a different evolutionary stage. We present here the results of the ISOCAM survey obtained at 6.7 and 14.3 μm (TDT no.11500619, 11500620) combined with near-IR observations taken at the NTT ESO telescope.

[CII] 157.7 μm line in absorption towards the galactic centre: connection with bright IR galaxies

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High spectral resolution Fabry-Pérot data are presented for the centre of the Sagittarius B2 complex (Sgr B2) around the fine structure lines of [CII] at 157.7 μm and the [OI] lines at 63.2 and 145.5 μm. The data were obtained with the Long Wavelength Spectrometer on board the Infrared Space Observatory. Both the [OI] 63.2 μm and the [CII] 157.7 μm lines are detected in absorption. The upper state level of atomic oxygen at 145.5 μm is in emission. Whereas the [OI] 63.2 μm line is seen in absorption over the entire wavelength range -200 to 100 km s^{-1}, the [CII] 157.7 μm line displays a more complex profile: absorption occurs at velocities $<$20 km s^{-1} with an emission profile from the Sgr B2 complex at velocities greater than 20 km s^{-1}. Using CO isotopes and HI data, absorption components can be associated with many clouds along the Sagittarius B2 line of sight. From these data, we are able to disentangle three different layers which contain atomic oxygen. These layers, as predicted by Photo-Dissociation Regions models (see for example Hollenbach & Tielens 1999), are characterized by different forms of carbon in the gas phase, i.e. the C^+ external layer, the C^+ to C^0 transition and the CO internal layer.
From a line shape modelling, a total column density of atomic oxygen in the line of sight to Sgr B2 of about 3.1×10^{19} cm^{-2} is derived within the clouds with velocities between -120 km s^{-1} and +10 km s^{-1}. Less than 30 % of this total O^0 column density is found to be due to the external layers of the clouds (where C^+ is the major form of carbon). The method used in that study leads to an estimate of the oxygen content in the intermediate layer where C^0 is the dominant form of carbon. The atomic carbon column densities derived here for the galactic clouds, with a mean value about 3×10^{17} cm^{-2}, are in good agreement with recent observations of the [CI] 492 GHz line (see Usuda et al. *in preparation*). The derived C^0/CO ratios are indicative of clouds, ranging from diffuse to dense, along the line of sight of the Sgr B2 HII complex, which have been fragmented and illuminated by the galactic interstellar radiation field. C^+/C^0 ratios close to 2 are derived for the clouds at galactocentric distances of 3 - 4 kpc, and ratios less than 0.6 for clouds in the galactic centre region.
The method used to disentangle the different layers of the clouds in the line of sight leads to the accurate computation of the O^0/CO ratio ($\sim$ 2.5) in the internal layers. Therefore, $\sim$ 70% of gaseous oxygen is in the atomic form and not locked into CO in the molecular clouds along the Sgr B2 line of sight.
The fact that the [CII] 157.7 μm line is detected in absorption implies that the main cooling line of the interstellar medium can be optically thick especially in the direction of large star-forming complexes or the nuclei of galaxies. This could partially account for the deficiency in the [CII] 157.7 μm line which has been recently found towards infrared bright galaxies (Malhorta et al. 1997; Luhman et al. 1998).

Future instrumentation will enable the present analysis to be improved. The Herschel project, with its high spectral resolution (HIFI) capability, will allow to better characterize the physical conditions of these clouds along the line of sight to Sgr B2 (and maybe on other lines of sight in direction of the galactic centre as well), in particular from the C^+ and C^0 lines and from high J transitions of CO. SMA and ALMA will provide high spatial resolution C^0 observations of these clouds necessary to separate each of the clouds. At high spectral resolution, the fundamental transitions of atomic oxygen will only be accessible to the second instrument generation on board the SOFIA observatory.

Session VII:

GALAXIES

ISM of Normal Galaxies

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What did we learn from ISO observations, especially of the far-IR fine-structure lines, about the ISM in star-forming galaxies? We identified a number of phenomenological trends in the data, relating line emission to continuum dust emission in the far-infrared, and the mid-infrared, including the tendency of CII(158um)/FIR emission to decline as the intensity of heating in the ISM increased, and the tendency of the ratio of OI($63\mu m$)/CII($158\mu m$) to increase at the same time. We compared those data to models of emission from Photo-Dissociation Regions and HII regions, and were able to constrain the range of heating intensities and gas densities in these systems. We also found and dealt with limitations to the applicability of these models, mostly in the nature of multiple contributions to the same line flux.

What remains to be done? A synthesis of what we learned from line emission work and dust emission work would greatly benefit the interpretation and global modelling of star-forming galaxies. Such modelling could then be extrapolated to more primordial systems to guide the planning for Early Universe exploration. In addition, there are empirical rules one could derive from a more thorough statistical analysis of the Local Universe galaxies that should also be helpful in the exploration at higher redshifts, and quide the planning in particular for SIRTF and Herschel.

ORAL PRESENTATION

Infrared Emission Spectrum of the Galacxy and External Galaxies Based on the IRTS and ISO Archival Data

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We have investigated the infrared spectral energy distribution (IR SED; 12-200 μm) of nearby galaxies in relation to the IR SED of the Galactic plane by using the IRTS/FILM 155 μm (Shibai et al. 1994, Okumura et al. 1996) and ISO/LWS 155 μm data in addition to the IRAS data to study the properties of interstellar dust grains in our Galaxy and galaxies. The ISO/LWS data are taken from the ISO archival data of LWS01 observations (e.g., Negishi et al. 2001) or estimated from the contiguous continuum of LWS02 observations of [CII]158 μm emission (e.g. Malhotra et al. 2001). The galaxy sample consists of normal spirals and galaxies. The data for $\lambda > 100\,\mu$m is indispensable to correctly estimate the far-infrared emission from submicron dust grains by excluding the contribution from very small grains. We have found that (i) the 12 μm emission correlates fairly well with the far-infrared color ($f(100\,\mu\mathrm{m})/f(155\,\mu\mathrm{m})$) and that dust models including PAHs and temperature-fluctuating very small grains explain the trend of the 12 μm emission relative to the far-infrared emission in the Galactic plane and external galaxies, but (ii) the emission of 25–60 μm shows a large scatter when plotted against the far-infrared color and dust models do not account for the observations of the 25–60 μm emission of the Galactic plane and galaxies consistently. Taking account of the fact that the 25–60 μm emission intensity of our Galaxy is approximately proportional to the square of the far-infrared intensity, being different from the model prediction (Okumura 1998, Onaka 2000), we then derived the empirical relation between the IR SED and the far-infrared color from the observations of the Galactic plane and applied it to the observations of external galaxies. The empirically derived IR SED accounts for the IR SED of a majority of the sample galaxies relatively well, but the emission of 25–60 μm is clearly weak compared to the empirical model in some galaxies, suggesting that the 25–60 μm emission has a different origin from the far-infrared emission and behaves independently of the 12 μm and far-infrared emission. These results provide a significant database for near future infrared survey observations to be carried out by SIRTF, ASTRO-F, and HSO.

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The Small Magellanic Cloud in the Far Infrared

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For the first time, ISOPHOT generated a complete map of the SMC at 170μm which combines good S/N values with high spatial resolution. A complex restoration process finally leads to an SMC map with 40" pixel size and a FWHM of 2'. The main morphological features and global properties (dust temperature, dust mass, FIR luminosities) of this map are discussed. Hundreds of FIR sources are extracted using an automated photometry program enabling accurate photometric characterization of the emitting regions. In order to compare the 170μm results with earlier IRAS data, the 12μm, 25μm, 60μm, and 100μm IRAS high resolution maps of the SMC are analyzed using the same numerical method. This provides a final all-band ISO/IRAS source catalogue which is not based on eyeball classification schemes, but relies on an algorithm which is capable of automated, repeatable photometry, even of irregular sources in crowded fields. The values of the total FIR luminosity, dust mass, gas-to-dust ratio, and the average dust temperature differ significantly from those of the pre-ISO era.

INVITED TALK

Normal Galaxies in the FIR

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The sensitivity of ISO and its spectral grasp extending to 200 μm made it the first observatory capable of routinely measuring the infrared emission corresponding to the bulk of starlight absorbed by interstellar dust in normal galaxies. Here the term "normal" denotes star-forming systems not undergoing a starburst, and not dominated by AGN activity. I will review the morphological and spectral characteristics of the dust continuum emission from normal galaxies emitted in the 40-200 μm spectral range, as revealed by detailed mapping observations of nearby spirals and by statistical studies of the integrated emissions from representative samples in the local universe.

Typically, and in contrast to starburst galaxies, the observed spectral energy distributions (SEDs) of normal galaxies are broad, with both warm and cold dust emission components, implying that grains are exposed to a wide range of intensities and/or colours within the interstellar radiation fields. Grains predominantly radiating longwards of 100 μm generally carry most of the FIR luminosity, and their mass constitutes virtually all the dust mass in normal galaxies. The dependence of the luminosities and dust masses on independent diagnostics of star-formation activity, on environment and on morphological type will be reviewed (including the dependences for dwarf galaxies), and a quantitative assessment of the overall energy budgets given. Possible solutions for the geometrical distributions of dust and stellar populations in normal galaxies, and which are in agreement with the observed UV/optical - FIR/submm SEDs, will be identified. The resulting implications for the relation between FIR emission and star-formation rate (SFR), as well as for the converse relation between UV/optical emission and SFR will be summarised. I will highlight the relevance of the ISO observations of local universe normal galaxies to our understanding of the role played by these systems in the star formation history of the universe. Several associated open questions will be amenable to future studies using the ISO archives, SIRTF, ASTRO-F and Herschel.

Extragalactic Research with ISOPHOT Pipeline Products

U. Klaas[1] on behalf of the ISOPHOT Data Centre Team

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Several extragalactic research projects on ULIRGs, Seyferts, quasars and normal galaxies are presented, which made direct use of ISOPHOT pipeline (OLP) data sets from the Legacy ISO Data Archive. The OLP products of several observing modes, like spectrophotometry and FIR raster mode photometry, have now sufficient photometric accuracy and are well characterized.

INVITED TALK

ISO SPECTROSCOPY OF BRIGHT GALACTIC NUCLEI

D. Lutz

Distant dust - high redshift in the ISO archive

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At high redshifts (z>0.3) dusty sources like ULIRGs, quasars, radio galaxies and lensed galaxies are well detectable with ISOPHOT and ISOCAM. Our new knowledge of these classes of active galaxies and future issues are reviewed.

ORAL PRESENTATION

A Mid-infrared Spectroscopic Atlas of Starburst Galaxies

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We present a mid-infrared (MIR) spectroscopic atlas of starburst galaxies as an example of scientific analyses of coherent samples extracted from the ISO Data Archive (IDA). Our ongoing work is centred around sub-samples extracted from a large SWS sample including a variety of sources. The sub-samples are selected according to clearly defined scientific objectives, collating and (re-)reducing all SWS data available from the IDA.

One such project is the analysis of the emission properties of a sample of local starbursts with detailed MIR SWS spectra. The spectra are rich in fine structure (FSL) and hydrogen recombination lines and thus are excellent probes to investigate the nature of starbursts. We use FSL ratios of Ne, Ar and S to construct diagnostic excitation diagrams and, in combination with H-recombination line data, we determine their elemental abundances.

Starburst galaxies are energetically dominated by massive, young, hot stars ionising the interstellar medium but the properties and evolution of this population are difficult to constrain for dusty objects where the direct stellar UV radiation is unobservable. Metallicity, the IMF and evolution will all affect integrated (observable) properties such as luminosities, colours and line strengths. Starbursts display low excitation with respect to Galactic HII regions which has been attributed to an IMF with low upper mass cut-off or ageing of the most massive stars. The dependence of both stellar evolutionary tracks and nebular properties on metallicity suggests to consider elemental abundances in this issue. By relating our calculated abundances to nebular excitation we may probe the hot star population and perform consistency checks with an ageing scenario.

In a related sub-sample, Sturm et al. present a systematic (re-)reduction of SWS spectra of Seyfert galaxies. We compare our starburst results to those of the Seyferts in order to derive diagnostic diagrams discriminating the two types of activity on the basis of their mid-infrared spectra.

The data presented will be useful as a reference for observations of fainter and/or higher redshift sources with future IR observatories such as SIRTF and Herschel.

Mid-IR Radiation of 3C Radio Galaxies: I. Observations and Models

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We have carried out a mid-infrared survey of 3C radio galaxies by extracting all ISOCAM observations of such objects from the ISO archive. The goal of this survey is to investigate the prevalence of hot dust in galaxies at a typical redshift of about 1. The data were calibrated in a uniform manner. A total of 75 radio galaxies were detected. To analyze these data, we have developed a data base of synthetic spectral energy distributions by solving the radiative transfer equations of dust clouds with AGN as primary heating source. We will discuss the motivation and application of these models to our survey.

ORAL PRESENTATION

Mid-IR Radiation of 3C Radio Galaxies II. Results

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The spectral energy distribution of 3C galaxies was constructed by compiling measurements in optical, near IR, far-IR and at mm bands for galaxies detected in our ISOCAM survey. Exploiting the models discussed in the previous talk, we will argue that for a large fraction of the detected galaxies, hot dust is the most likely explanation for the mid-infrared emission. Where this is the case, we have derived the total infrared luminosities, dust mass and limits on the dust temperatures. Taking into account selection biases in our sample, we will discuss the frequency and properties of hot dust in radio galaxies at high redshift.

Multi-wavelengths analysis of dust emission from the Small Magellanic Cloud

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The ISO Data Archive provided us a large set of PHOT observations at 170 microns, covering a large fraction of the SMC, that we combined into a large (4 deg^2) map.Together with IRAS and ATCA/Parkes HI Observations, we analysed this dust emission map.

Part of the structure in the PHOT maps correlates with the HI distribution. This leads to the determination of the large dust grains temperature and abundances. On the other hand, some peculiar regions show either an excess or a lack in dust emission with respect to the emission expected from dust in the HI gas. These differences can trace variations in dust heating, dust abundances and also dust in molecular gas or HI gas too cold to be seen in emission.

A dust temperature map derived from the comparison of the PHOT and IRAS data allows us to disentangle these possibilities.

For these study we had to collect data from different instruments via data bases and combine them. This allowed us to have a multi-wavelenghth view of phenomenons, and is then a first example of research on the ISO archive in the contextof virtual observatories.

POSTER

Investigating the [CII]–PAHs relation with a large (∼150) sample of local galaxies

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We discuss the linear correlation existing between the Mid Infrared Aromatic Emission Feature (AFEs) and the [CII] emission at 158μm for a sample of 150 galaxies. The [CII] line is the main cooling line of the atomic neutral gas. It is heated principally through photo-electric effect on grains after Far UV photons absorption. On a sample of 69 normal galaxies, Helou et al. (2001) showed that while the [CII]/FIR ratio decreases with the galaxy activity (Malhotra et al. 2001), the [CII]/AFE ratio stays constant. Although this result confirms that AFE carriers are the most efficient among all grain populations at heating the atomic neutral gas, such different behaviour between different grain populations is puzzling. To explain the decreasing of the [CII]/FIR ratio with the galaxy activities, Malhotra et al.(2001) suggested that is the increasing of the grain charge to lower the photo-electric efficiency. However, the same phenomenon is expected to hold also for the AF carriers, although to a smaller extent. If this is true, there must be another mechanism(s) capable to tight together the [CII] and AFEs, making them proportional, whatever is the galaxy activity. Helou et al.(2001) proposed different interpretation which need to be further investigated. With this in mind and in order to better understand this micro–physic, we conducted an analysis similar as in Helou et al. (2001) with a much larger sample constituted by all galaxies observed with both ISO–CAM (LW2) and ISO–LWS at 158 μm, expanding the Helou et al. (2001) sample to both the quiescent and active sides of the relation outlined by normal galaxies, and including starburts, AGNs, and ULIRG. In this poster we present the preliminary results and discussion.

What powers the PAH emission in galaxies?

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Mid-infrared spectra and submillimetre maps are investigated for five galaxies covering a range of star forming activity. We find a good spatial coincidence between the 850 μm continuum emission and the strength of the PAH 7.7 μm line. The PAH 7.7 μm peak to 850 μm flux ratio lies in the range around 2 with a moderate dispersion across the galaxies. Both PAH and cold dust emission correlate also with the emission from very small grains at 14.3 μm, but regions with starbursts show an excess in the very small grain emission. This suggests that the PAH carriers are preferentially related to the regions dominated by cold dust and molecular clouds, where they are excited mainly by the interstellar radiation field. The lack of increased PAH/submm ratio in starburst knots suggests that starbursts play a minor role for powering the PAH emission in galaxies.

POSTER

ISOPHOT's Serendipity Survey discovers an unusually cold ultraluminous infrared galaxy

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We present multi-wavelength follow-up observations of the newly discovered ultraluminous infrared galaxy ISOSS J 15080+7248. This object was detected in the ISOPHOT Serendipity Survey (ISOSS) database by the search for cold and luminous extragalactic sources. The derived dust temperature from the combination of ISOPHOT, IRAS and ground-based MAMBO photometry is 21 K. This is remarkably low for a system with a luminosity of $L_{FIR} = 2 \cdot 10^{12}$ $L_\odot$ and challenges the current paradigm that the high redshift submm galaxy population consists of scaled analogs of the known much warmer ($T_d \sim 40$ K) ULIRGS of the local universe. If this source represents a prototype member of a new class of galaxies, their significant submm excess emission of cold dust could considerably contribute to the submm background radiation.

The source is associated with an optically bright elliptical galaxy (M_V = -23.5 mag) at redshift z=0.213 as found from direct images and spectra obtained at the Calar Alto observatory. The gas-to-dust ratio derived from ^{12}CO molecular line observations at the IRAM 30m telescope is as low as 10.

The exhaustion of molecular fuel, the low dust temperature and the optical characteristics of an elliptical galaxy let us suggesting, that ISOSS J 15080+7248 is a late-phase ULIRG undergoing its transition into a massive elliptical system. Such sources have been overlooked in surveys based on the IRAS data due to its wavelength cutoff at 100 μm. The ISOPHOT Serendipity Surveys allows for the first time to search for such rare classes of FIR emitters.

The Complex Far-Infrared Morphology of M86

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Archival imaging data of the Virgo cluster elliptical M86 (NGC 4406) obtained with ISOPHOT at 60, 90, 150 and 180 μm reveal a quite complex far-infrared morphology. A close pair of compact sources is associated with the M86 galaxy itself, the spectral energy distributions of which are rising strongly towards longer wavelengths, indicating the thermal emission of cold dust with a temperature of about 18 K. A third unresolved FIR source, previously discovered by IRAS, lies about 3.5 arcmin north-west of M86. Its spectral energy distribution is, in contrast, strongly decreasing with wavelengths. A fourth source about 7.5 arcmin north-west of M86, close to the nearby edge-on spiral NGC 4402, consists of a compact central core surrounded by an extended halo, and is positionally coincident with a steep decline in X-ray emission. Its brightness is also rising steeply with increasing wavelengths, again indicative of cold dust.

These results provide a vast improvement over earlier FIR studies based on IRAS data, where at 100 μm only a compact component close to M86 itself, and at 60 μm additionally an extended structure about 3.5 arcmin north-west of M86 close to extended X-ray emission had been found. The new ISOPHOT data do not support the interpretation based on IRAS and X-ray data that the north-western component is cold dust removed from the galaxy by ram pressure stripping while moving through the dense intracluster medium. Particularly, it has a rather warm dust temperature of about 60 K, lies away from the ridge of the extended X-ray emission, and is positionally coincident with an optically faint unresolved point source, most likely an unrelated background source.

The central double source also does not support the interpretation of cold interstellar matter swept back during interaction with the intracluster medium, since the eastern component not coincident with the M86 galaxy centre is displaced from the nucleus along the direction of the velocity vector derived from X-ray data. Instead the eastern component is likely related to optically discovered dust streamers attributed to ram stripped dust from the faint companion galaxy VCC 882. Eventually, the fourth cold source lying between M86 and NGC 4402 is likely part of the interstellar medium of NGC 4402 tidally removed during the passage of M86.

Overall, the observational evidence strongly suggests that for the FIR morphology gravitational interactions between M86 and neighbouring galaxies are much more important than ram stripping. Since M86 is clearly not showing signs of on-going stripping of interstellar dust by intracluster gas, a clear case for this dynamic interaction has yet to be found. It is planned to analyze other archival data to investigate the influence of gravitational interactions on the dust distribution of galaxies.

POSTER

Infrared Emission from Elliptical galaxies: The case of NGC4649, NGC4472, and NGC4636

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We present ISOPHOT P32 oversampled maps of a sample of bright early-type galaxies in the Virgo Cluster. The maps reach the limiting sensitivity of the ISOPHOT instrument at 60, 100, 170 and 200μm. Three of the brightest early-type local galaxies clearly show no emission at far-IR wavelengths at a level of few tens of mJy. The null detection at all wavelengths performed by ISOPHOT is crucial to test the expected far-infrared emission produced by distributed dust in elliptical galaxies, as well as to constrain the dust composition, size distribution, and grain evolution, with particular emphasis to the sputtering process.
As previous studies have shown, in many elliptical galaxies both IRAS and ISO have detected mid-IR excess 6-15 micron emission relative to the stellar continuum, indicating emission from circumstellar dust. Under the assumption that these dusty outflows from evolving red giant stars and planetary nebulae are continuously supplying dust to the interstellar medium, we have computed the infrared luminosity at the ISOPHOT bands for appropriate models of elliptical galaxies. We present new insights into the physical mechanisms which control the dust grain evolution in these galaxies.

A flux calibration of ISOCAM ELAIS catalogues and infrared colours of star-forming galaxies in ELAIS fields

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We present J and K-band near-infrared photometry of a sample of ISOCAM sources detected by the European Large Area *ISO*-Survey (ELAIS). All of the high-reliability LW2 sources and 80 per cent of the high-reliability LW3 sources are identified in the near-IR survey reaching $K \approx 17.5$ mag. The detection efficiencies for lower reliability sources are 88 and 35 per cent at LW2 and LW3 bands, respectively.

The near- to mid-IR flux ratios can effectively be used to separate stars from galaxies in mid-IR surveys: at 6.7 μm, 80 per cent of the identified ELAIS objects are stars while at 15 μm, 80 per cent of the near-IR identified ELAIS sources are galaxies. The stars are then used to perform an accurate new calibration of the ELAIS ISOCAM data at both 6.7 and 15 μm: we adopt values of 1.23 and 1.05 ADU/gain/s/mJy for the LW2 and LW3 filters, respectively.

We show that near to mid-IR colour-colour diagrams can be used to further classify galaxies, as well as study star-formation. In a [15/2.2] vs. [6.7/2.2] plot the Hubble type of a galaxy can be roughly estimated from its position along the diagonal ($[6.7/15] = 1$) and the star-forming efficiency from a galaxy's departure from the diagonal (eg. $[6.7/15] < 1$). The ISOCAM ELAIS survey is found to mostly detect strongly star-forming late-type galaxies, possibly starburst powered galaxies, and it also picks out obscured AGN. Only one third of LW3 galaxies are also detected in LW2 (the faintest population of late-type star-forming spirals and starbursts is missed by the LW2 filter), while two thirds of LW2 galaxies are seen in LW3. The few objects missed by the longer mid-IR filter are most probably early type galaxies. Simple arguments indicate that typical redshifts of the sample seen with both mid-IR bands are $z \leq 0.2$.

The ELAIS galaxies yield an average mid-IR flux ratio LW2/LW3 $= 0.67 \pm 0.27$. We discuss this [6.7/15] ratio as a star formation tracer using *ISO* and *IRAS* data of a local comparison sample. We find that the [2.2/15] ratio is also a good indicator of activity level in galaxies and conclude that the drop in the [6.7/15] ratio seen in strongly star-forming galaxies is a result of both an increase of 15μm emission and an apparent depletion of 6.7μm emission.

POSTER

ISO Photometry of Hyperluminous Infrared Galaxies: Implications for the origin of their extreme luminosities

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We present 7-180μm photometry of a sample of hyperluminous infrared galaxies (HyLIGs) obtained with the photometer and camera mounted on the *Infrared Space Observatory*. We model their broad-band spectral energy distributions (SEDs) using 'state-of-the-art' radiative transfer models of obscured starbursts and dusty torii. We find that IRAS F00235+1024, IRAS F14218+3845 and IRAS F15307+3252 require a combination of starburst and AGN components to explain their mid to far-infrared emission, while for TXS0052+471 an AGN dust torus model alone is sufficient. For IRAS F00235+1024 and IRAS F14218+3845 the starburst component is the predominant contributor whereas for IRAS F15307+3252 the dust torus component dominates. The implied star formation rates (SFR) for these three sources estimated from their infrared luminosities are $\dot{M}_{*,all} > 10^{3.5} M_{\odot} yr^{-1} h_{50}^{-2}$ and are amongst the highest SFRs estimated to date. We also demonstrate that the well-known radio-FIR correlation extends into both higher radio and infrared power than previously investigated. The relation for HyLIGs has a q value of ~ 1.94.

The results of this study imply that better sampling of the IR spectral energy distributions of HyLIGs may reveal that both AGN and starburst components are required to explain their emission from the NIR to the sub-millimetre.

In addition, comparable studies of larger samples of luminous IR galaxies will be briefly outlined for which we are collating and reducing data (where necessary) from the ISO Data Archive.

Session VIII:

COSMOLOGY AND DEEP SURVEYS

ISO and the Cosmic Infrared Background

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The infrared part of the electromagnetic spectrum is a key domain to study galaxy formation and evolution, since most of the energy emitted by the galaxies at every epoch, the Extragalactic Background Light, is released between 10 and 800 microns, with a peak around 150 microns: this is the Cosmic Infrared Background (CIB).

The Deep Surveys conducted with ISO using ISOCAM in the mid-infrared, and ISOPHOT in the far infrared, allowed to probe to some extend the nature of the galaxies that created the CIB, using tools such as source counts or fluctuation analysis. The ISO data, widely available through the ISO data archive, is a legacy for understanding galaxy evolution at moderate redshift. It's also important for preparing the future space infrared observations with SIRTF and Herschel, as well as for eventually comparing and correlating in a complementary way the data from these observatories.

I will review the Deep Surveys conducted with ISO and their results, with an emphasis on the 15 and 170 microns surveys. I will also review the data of potential interest for studies of the CIB. I will finally present how the ISO data help to plan the deep surveys to be conducted with SIRTF.

ORAL PRESENTATION

A mid-infrared look of the Lockman Hole.

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The Lockman Hole was one of the main targets of the Guaranteed Time Deep Surveys with ISOCAM. Three surveys were performed in this field: a shallow one covering $40' \times 40'$ at 15 μm and two deep surveys covering $20' \times 20'$ at 6.75 μm and at 15 μm.

We present the reduction of these observations with the new technique developed by Lari et al. (2001) which allow us to completely exploit the potential of the ISOCAM data. In particular, we are able to detect 240 sources in the shallow survey down to a flux of 0.5 mJy and 300 sources in the deep survey at 15 μm down to a flux of 0.3 mJy.

Thanks to the intensive photo-spectroscopic follow-up observations, almost all the sources have optical counterparts and the redshift distribution of 15 μm in this field is now well defined and peaks around $z = 0.6$.

The counts at 15 and 6.75 μm are presented and the effect of the presence of a large scale structure in the field is evaluated. Finally, cross-correlations with radio and X-ray data to study the star-formation and AGN contribution to the infrared extragalactic emission are discussed.

ISO Lensing Survey - background galaxies and foreground cluster properties

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A number of ISO programmes, totaling nearly 66 hours of observation time, made use of the gravitational lensing phenomenon to extend the sensitivity of ISO observations. Substantial results derived from this time have been published, or are in the peer review process, addressing the MIR properties of the background lensed galaxy population. These results, which have important implications for galaxy evolution, and which resolve a large fraction of the 15 and 7 micron infrared-background light, will be briefly summarised. But the data has much further potential. Little has been published to date concerning the implications of the ISO lensing data for the foreground clusters themselves, nor addressing the overlap between the observed ISO sources and lensed populations seen at X-ray and Sub-mm wavelengths.

In addition to recalling briefly the published results on background populations we report on an ongoing programme to systematically re-analyse the set of ISO observations of lensing galaxy clusters (this part being substantially completed), and then to describe and compare the IR properties of the foreground clusters and to study the overlap between ISO source lists and recently published lists of X-Ray and Sub-mm populations in these fields.

ORAL PRESENTATION

A far-infrared view of the Lockman Hole from ISOPHOT

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An important advance in the knowledge of the nature of galaxies is possible only using mid- and far-infrared data. In particular, the deep and extended surveys performed by the satellite ISO are suited for this kind of study.
We present our preliminary results of the analysis of the PHOT 90 μm data in the Lockman Hole with a recently developed technique (Lari et al. 2001). The survey covers an area of $40' \times 40'$, and is complementary to the shallow survey in the mid-infrared by ISOCAM. We are able to detect 25 sources down to a flux of 50 mJy. In particular, we discuss the cross-correlations between the far- and the mid- infrared sources. For the sample of sources detected in both IR bands, it becomes possible to study in detail the SEDs exploiting optical data (photometry in several bands and spectroscopy). Moreover, the 90μm flux is a good measure of the bolometric luminosity and allows to evaluate the global star formation. Finally we study the relation between the 15μm and 90μm fluxes, in order to verify if the mid-IR flux is a good tracer of star formation. The availability of X-ray data in the Lockman Hole allows us also to distinguish AGNs from starburst galaxies.

ELAIS Data Reduction with the LARI Method: Final Analysis of ISOCAM LW3 Fields

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The ELAIS survey was the largest Open Time project carried out with ISO, covering 13 deg^2 at 15 and 90 μm and smaller areas at 6.7 and 175 μm. Thanks to an extensive multi-wavelength coverage, the ELAIS fields are now amongst the best studied sky areas of their size.

We present the results of the Final Analysis of ELAIS ISOCAM LW3 fields, carried out with the LARI Method (Lari et al. 2001), a new technique specifically developed for the detection of faint sources in ISOCAM and ISOPHOT maps. A catalogue of great reliability and completeness including about 2000 sources in the 0.5 – 100 mJy flux range was obtained, roughly four times more than obtained with the original Preliminary Analysis and the largest catalogue provided to date by any single ISO project.

The reliability, completeness and photometric accuracy of the catalogue at different flux levels are discussed through simulations.

Preliminary 15 μm differential number counts show an abrupt slope change at $\simeq$ 2 mJy, where they are also significantly lower than other published ISO results.

Finally, the large-scale clustering of 15 μm sources is discussed.

POSTER

The European Large Area Iso Survey: 90μm number counts

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The European Large Area *ISO* Survey (ELAIS) was the largest single Open Time project conducted by *ISO*, mapping an area of 12 square degrees at 15μm with *ISO-CAM* and at 90μ with *ISO-PHOT*.

We shortly present the data analysis of the 90 μm survey. We carefully calibrated the data using standard stars and show comparisons with IRAS for point sources and COBE/DIRBE for surface brightnesses. The large number of rasters necessary to cover the wide ELAIS areas allows to compute a relative uncertainty for the calibration based on the FCS of typically 7%. The absolute calibration is better than 20%.

The survey is at least an order of magnitude deeper than the IRAS 100μm survey and is expected to provide constraints on the formation and evolution of galaxies.

Finally, we present 90 μm number counts from a reliable subset of the detected sources. ELAIS number counts are compared with evolutionnary models and other surveys in the far infrared.

Session IX :
(POSTERS ONLY)

NEW DEVELOPMENTS IN DATA REDUCTION

The memory effect of the ISOPHOT-C100 detector

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Data in the ISO archive can be used to study the behaviour of the instrument, which in turn leads to an improved data reduction.

We present our work on the ISOPHOT-C100 detector. The large amount of archive data allowed us to study the memory effect of the C100 pixels during staring observations. The signal of the C100 detector is usually fitted by an offset exponential as a function of time. Our results show a clear relation between the parameters of that offset exponential and the previous flux that has been measured by the detector. Using this information, one can reduce the number of parameters needed to fit the observed signals.

While the present work is still limited to staring observations, it has obvious implications for chopping observations as well.

POSTER

Frequently Asked Questions about the transient correction of ISOCAM data Perspectives for SIRTF and ASTRO-F

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It has been shown that, under uniform illumination, the transient response of individual pixel of LW ISOCAM detector can be described with high accuracy by one of the Fouks' model, the so called Fouks-Schubert one. Since this model is highly non linear and need a good initialization (knowledge of the prehistory of the observation) to be accurately inverted, several problems were encountered using the correction method presented in Coulais and Abergel (2000). We review here what should be checked before applying this correction method.

We illustrate why we are very sensitive to the dark correction and to the prehistory. Several data may give extra complication or cannot be processed by a definitive way. We also show that several observing modes were not convenient in order to ensure a reliable transient correction (e.g. one direction CVF).

The Fouks-Schubert model and similar non linear ones are also used for other ISO detectors, and will be likely used for future IR missions, especially for the Ge:Ga detectors on-board SIRTF (MIPS) and ASTRO-F (FIR). We know from ISO that the use of such models influences the observation strategy (e.g. minimization of the total exposure time, use of the spatial redundancy,...), the data splitting (we need to know what happen before the current observation !) and the design of the performance verification phase.

Improved calibration strategy for faint objects

Carlos del Burgo[1], et al.

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We have established a new calibration strategy for the ISOPHOT P- and C-detectors, particularly useful to perform fine absolute photometry at faint signal level. From all suitable ISOPHOT archive data we have reviewed different instrumental effects for P- and C-detectors and determined more accurately the zero point of these detectors, deriving new calibration files. Re-analysis of the reset interval transformation and the dark signal behaviour are presented in addition to a new method for the transient correction and, for C-detectors, the first determination of the by-passing sky light. The new data reduction procedure can be applied to determine faint signals.

POSTER

Accurate physical model for direct modeling of point source transients for ISOCAM LW detector

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Under quasi uniform illumination, the transient response of individual pixel of LW ISOCAM detector is described with high accuracy by one of the Fouks' model, called as Fouks-Schubert model. But this model fails its accuracy if the gradient of illumination between adjacent pixels is high.

We present here a general physical model which allows to describe with a high accuracy most of the cases we have with ISOCAM. Besides the case of quasi uniform illumination it is applicable also to the case of point sources. For the last case its accuracy becomes higher, the narrower is the source PSF. The transient response of the mean value of the 3×3 pixels centered of the brightest one is described at per-cent level. The transient response of individual pixels are described at few percent level. Worst cases for individual pixel are for lens 1.5 ArcSec, especially for filters LW 3, 9, 10 and 8. In order to receive a per-cent accuracy for these cases the model should be further developed. Preliminary results are shown on
`http://www.ias.fr/PPERSO/acoulais/ISO_Sources/transients_sources.html`

This model still uses the (β, λ) parameters which were used for the uniform illumination case. No supplementary parameters are required. Following the Fouks theory, these two parameters describing for each pixel the instantaneous jump (β) and the time constant (λ) are connected to the detector quality from the technology point of view. Dispersion of these parameter through the array indicates poorly controlled technological processes. Theoretical limits are also known. For ISOCAM, we found that (1) the bulk quality of the matrix array is rather good and is well uniform, but (2) the quality of contacts is not uniform and is far from theoretical limits. To be closer to these limits should give a transient response up to five time faster. Nevertheless CAM detector is a good one since it is described by the Fouks theory in a large range of incoming flux, which allows an accurate correction of its transient responses.

From the achieved knowledge of Si:Ga detector on-board ISO (CAM LW, SWS b2, PHT S and PHT P) following their behavior in respect to transients, to the sensitivity to the impact with HEPs, with the help of Fouks theory, it is now theoretically possible : (1) to design such a Si:Ga detector close to theoretical limits, (2) to control the quality of the detector during technological phases.

Up to now, no inversion method has been developed for the new model we present here. The problem is much more complicated than for the uniform case since we have to process at least the 3×3 pixels at the same time since we have to find three values of the source (two for position, one for its amplitude above the background) and the two values for the initial and final background. It is assumed that the source profile (PSF) is accurately known for each combination of filter and lens.

At the present time, the ISOCAM data contained in the archive and corresponding to fields with bright point sources or very steep gradients are still affected by transient problems, even after the "standard" transient correction. However, our new physical model can now be used to reconsider the point source photometry. The LW CAM wavelengths will not be covered by SIRTF and ASTRO-F. Finally, these efforts should be extremely useful for the next missions, since their detectors could also be affected by comparable problems for point sources.

The LARI Method for ISOCAM and ISOPHOT Data Reduction and Analysis

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The methods and software tools developed for the reduction and analysis of ISOCAM and ISOPHOT data with the LARI method are presented. The method, specifically designed for the detection of faint sources in ISO raster observations, is based on the assumption of the existence of two different time scales in the detectors' transient behaviour, accounting either for fast or slow detectors' response.

The specifically developed IDL software includes: a reduction pipeline performing basic operations such as deglitching, background determination and bright source detection; the fitting procedures proper, modelling the time history of individual pixels and detecting any flux excess ascribable to potential sources; mapping, source extraction and flux estimation procedures; simulation procedures allowing one to estimate the errors arising from different instrumental and reduction effects. Moreover, an easy-to-use Graphical User Interface allows one to quickly browse the data and carry out the amount of interactive analysis required when the fit fails.

This technique provides source lists of great reliability and completeness and an outstanding photometric accuracy, particurarly at low redundancy levels (e.g. on ELAIS fields), where the reliability of ISOCAM and ISOPHOT source lists at moderately bright flux levels has been a long standing issue.

A detailed description of our methods and software tools is given, alongside with some highlights from the results obtained thanks to their application to different fields. The completeness, reliability and photometric accuracy of the resulting source lists at different flux and raster redundancy levels is discussed through simulations. At higher redundancy levels and fainter fluxes, i.e. where such a comparison can only be carried out, our results are compared with those obtained with other methods.

POSTER

A full scale photometric investigation of the ISOPHOT minimap mode

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The release of the final version of the ISOPHOT Off-Line Processing software (OLP 10) and the generation of the ISO Legacy Archive closed the main period of the ISOPHOT calibration. In this phase the calibration pursued the main instrumental problems which affect several or all the observing modes. However, due to limitations of this general approach in many observing modes the ultimate photometric accuracy has not been reached yet.

One possibility for further improvements would be to understand the specific problems of individual observing modes and work out dedicated correction algorithms which are not neccessarily applicable to other modes. We propose the following general scheme for the analysis of a selected well-defined ISOPHOT observing mode:

1) Collect from the Archive all observations performed in the selected observing mode;

2) Identify all objects which could be used as photometric standards;

3) Process the measurements of identified standard objects using the best data reduction method available;

4) Search for systematic trends in the (Measured-Predicted) residual flux densities;

5) Try to understand the reason behind the observed trends and invent new data processing methods to eliminate it; or fit the observed trend and work out an empirical formula to correct for the systematic discrepancies;

6) Repeat Points 3-5 until no obvious trend can be detected;

7 Document the new processing methods and the empirical fits;

Using the new reduction methods optimised for the selected mode we will re-analyse the entire data set of that observing mode. In the framework of a join project of Konkoly Observatory and the ISO Data Centre the re-analysed data will be ingested to the ISO Archive.

In this contribution we present the recalibration of the ISOPHOT minimap mode as a first result of the cooperation.

Development of the ISOPHOT Pipeline during the Active Archive Phase

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The development of the ISOPHOT pipeline has continued at the UKIDC beyond V10 used to generate the ISO Data Archive(IDA). The reprocessing of selected subsets of the ISOPHOT observations have been carried out for bulk ingestion into the IDA. These include all chopped PHT-S observations and the mini-map observations with the PHT-C arrays. The improvements to the algorithms are described and some results showing the improvements and enhancements to the data products are presented. Finally the future developments involving subsets of the chopped photometric and PHT-C raster map observations are outlined.

POSTER

P32Tools: Reduction of ISOPHOT P32 Oversampled Maps

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During the ISO mission, the ISOPHOT instrument has collected more than 1100 observations in oversampled mapping mode (AOT PHT32) in the wavelength range of 45 to 240 microns. The observations comprise mapping of small and large extended regions, but also faint point sources. PHT32 observations are affected by strong signal transients due to flux changes generated by the relatively fast chopper movement. A program to correct for these effects, described in the poster by Tuffs & Gabriel, was developed at MPIKernphysik (Heidelberg), supported by the ISO Data Centre at VILSPA. This was integrated in the ISOPHOT Interactive Analysis (PIA) via a graphical user interface (GUI), which was developed at IPAC/Caltech in collaboration with VILSPA, so that most aspects of the processing can be addressed in a coherent and user friendly environment. The resulting package "P32TOOLS" was introduced to the user community at three hands-on workshops on PHT32 processing held in spring 2001. The hands-on experience from these workshops helped to further improve the package. The resulting proceedings include both, technical lectures and science papers illustrating applications of the new algorithm. In our poster we will present an overview of the functionalities of the new software, including the GUI, the underlying algorithms and relevant calibration issues.

Photometric Mapping with ISOPHOT using the "P32" Astronomical Observation Template"

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The "P32" Astronomical Observation Template (AOT) provided a means to map large areas of sky (up to 45×45 arcmin) in the FIR at high redundancy and with sampling close to the Nyquist limit using the ISOPHOT C100 (3×3) and C200 (2×2) detector arrays on board ISO. However, the transient response behaviour of the Ga:Ge detectors, if uncorrected, can lead to severe systematic photometric errors and distortions of source morphology on maps. Here we describe the basic concepts of an algorithm which can successfully correct for transient response artifacts in P32 observations. Examples are given demonstrating the photometric and imaging performance of ISOPHOT P32 observations corrected using the algorithm. Details of the implementation and usage of the algorithm in the "P32TOOLS" software package are given in the accompanying poster by Schulz et al.