SP-460
Abstracts

ESA Symposium

on

The Promise of FIRST

Toledo, Spain, 12-15 December 2000

European Space Agency
Agence spatiale européenne

Cover Picture:

View of Toledo, by El Greco
The Metropolitan Museum of Art, H.O. Havemeyer Collection

Scientific Programme

Monday 11 December 2000

16.00 Registration - until 20.00

Tuesday 12 December 2000

08.30 Registration

Session 0: Welcome

09.00 LOC: Welcome and Practicalities

09.10 Formal Welcome 1

09.20 Formal Welcome 2

Session 1: Introducing the FIRST mission

11.00 *Coffee break + mount posters*

Session 2: Introducing the FIRST instruments

13.00 *Lunch break*

Session 3: Introducing the context of FIRST

17.00 *Coffee break + posters*

Session 4: A taster of FIRST science

Wednesday 13 December 2000

Session 5: Extragalactic surveys & star formation

Session 6a: Extragalactic surveys

Session 6b: Star formation

Session 7: Far & near

Session 8ab: Panel discussions, part 1

Thursday 14 December 2000

Session 9: Galaxies & stars

Session 10a: Galaxies and galaxy clusters

Session 10b: Evolved stars and dust, part 1

Session 11a: Extragalactic spectroscopy and C^+

Session 11b: Water, ISM, and spectroscopy

Session 12ab..: Panel discussions, part 2

Friday 15 December 2000

08.30 Registration

Session 13: Circumstellar and interstellar matter

10.30 *Coffee break + poster dismounting*

Session 14a: Instruments

12.45 *Lunch break*

Session 14b: Galactic Surveys & Evolved stars and dust, part 2

12.45 *Lunch break*

Session 15: Panel reporting and conference summary

14.15 Panel discussion reports

16.15 Conference summary and wrapping up

16.45 END of formal programme

Session 1
Introducing the FIRST Mission

A general view of IR astrophysics

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The FIRST mission: Science objectives and this meeting

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The 'Far InfraRed and Submillimetre Telescope' (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 60−670 μm range.

FIRST 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. FIRST 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.

The key science objectives emphasize current questions connected to the formation of galaxies and stars, however, having unique capabilities in several ways, FIRST will be a facility available to the entire astronomical community. Once operational FIRST 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. In this meeting we want to discuss how best to use the available FIRST observatory time in order the maximise the scientific return from FIRST.

The FIRST mission: Implementation status and schedule

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The Far InfraRed and Submillimetre Telescope (FIRST) is one part of the ESA FIRST/Planck programme that combines two ESA missions of the HORIZON 2000 programme, the fourth cornerstone mission (CS4), FIRST, and the third medium sized mission (M3), Planck.

FIRST is a multi-user observatory, observing in the far infrared and sub-millimetre part of the electromagnetic spectrum, in the wavelength range from 60 to 670 µm. The Planck mission is a survey mission dedicated to map the anisotropies of the temperature of the cosmic background radiation.

Both missions are planned to be launched in February 2007 on a single ARIANE V launcher from the European Space Port of Kourou. The baseline scenario for the launch assumes the carrier configuration, i.e. FIRST is mechanically carried by the Planck spacecraft. Both missions use orbits around the 2nd Lagrangian libration point L_2, that is approximately 1.5 million kilometres away from the earth in the anti-sun direction.

The programme is now close to the start of the spacecraft development and the paper will give an overview on the FIRST system design, the planned overall project implementation and the actual status of the programme.

Session 2
Introducing the FIRST Instruments

The FIRST PACS Instrument

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The Photoconductor Array Camera & Spectrometer (PACS) is one of the three science instruments for ESA's Far Infra-Red and Submillimetre Telescope (FIRST). It employs two Ge:Ga photoconductor arrays (stressed/unstressed) with 16×25 pixels, each, and two filled Si bolometer arrays with 16×32 and 32×64 pixels, respectively, to perform imaging line spectroscopy and imaging photometry in the $60 - 210\mu$m wavelength band. In photometry mode, it will simultaneously image two bands, $60-90$ or $90-130\mu$m and $130-210\mu$m, over a field of view of $\sim 1.75' \times 3.5'$, with full beam sampling in each band. In spectroscopy mode, it will image a field of $\sim\ 50'' \times 50''$, resolved into 5×5 pixels, with an instantaneous spectral coverage of ~ 1500km/s and a spectral resolution of ~ 175km/s. In both modes background-noise limited peformance is expected, with sensitivities (5σ in 1h) of ~ 3 mJy or $2 - 8 \times 10^{-18}$W/m^2, respectively.

The FIRST-SPIRE Instrument

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SPIRE, the Spectral and Photometric Imaging Receiver, will be a bolometer instrument for ESA's FIRST satellite. Its main scientific goals and design drivers are deep extragalactic and galactic imaging surveys and spectroscopy of star-forming regions in own and nearby galaxies. The instrument comprises a three-band imaging photometer operating at 250, 350 and 500 µm, and an imaging Fourier Transform Spectrometer (FTS) covering 200-670 µm. The SPIRE detectors are feedhorn-coupled NTD spider-web bolometers cooled to 300 mK by a recyclable ^{3}He refrigerator. The photometer has a field of view of 4 x 8 arcminutes which is observed simultaneously in the three spectral bands. Its angular resolution is determined by the telescope diffraction limit, with FWHM beam widths of approximately 17, 24 and 35 arcseconds at 250, 350 and 500 µm, respectively. An internal beam steering mirror can be used for spatial modulation of the telescope beam, and observations can also be made by drift-scanning the telescope without chopping, providing better sensitivity for source confusion limited deep surveys. The FTS has a field of view of 2.6 arcminutes and an adjustable spectral resolution of 0.04 - 2 cm^{-1} ($\lambda/\Delta\lambda$ = 20 - 1000 at 250 µm). It employs a dual-beam configuration with novel broad-band intensity beam dividers to provide high efficiency and separated output and input ports. The instrument design, operating modes, and predicted sensitivity will be described.

The Heterodyne Instrument for FIRST

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The Heterodyne Instrument for FIRST, *HIFI*, has been optimised to address astronomical key questions that require high spectral resolving powers and sensitivity. These studies range from planetary atmospheres, comets, collapsing molecular clouds forming new stars and planetary systems, stellar winds associated with dying stars, the origin and evolution of the general ISM, galactic nuclei, to nearby and distant dusty galaxies.

The instrument is designed to have the following capabilities:

- continuous frequency coverage from 480 to 1250 GHz in five bands, while a sixth band will provide coverage for 1410-1910 GHz,
- an instantaneous bandwidth of 4 GHz analysed in parallel by two types of spectrometers: a pair of wide-band spectrometer (WBS), and a pair of high-resolution spectrometer (HRS) providing
- resolving powers up to 10^7 (300 – 0.03 km/s)
- detection sensitivity close to the theoretical quantum noise limit.

Session 3
Introducing the Context of FIRST

The Results of ISO

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The *Infrared Space Observatory (ISO)* was the world's first true orbiting infrared observatory, providing astronomers with unprecedented sensitivity and capabilities at infrared wavelengths from 2.5 to around 240 μm with spatial resolutions ranging from $1.5''$ (at the shortest wavelengths) to $90''$ (at the longer wavelengths). Launched in November 1995 and operational until April 1998 – almost a year longer than specified, ISO was a great scientific, technical and operational success. Its 60cm-diameter telescope was was cooled by superfluid liquid helium to temperatures of 2-4K. ISO was equipped with four highly-sophisticated and versatile scientific instruments, two spectrometers a camera and an imaging photopolarimeter. At a wavelength of 12 μm, ISO was one thousand times more sensitive and had one hundred times better angular resolution than IRAS. Some 30000 individual imaging, photometric, spectroscopic and polarimetric observations were made of all classes of astronomical objects and these data are now available to all from the ISO Data Archive at `www.iso.vilspa.esa.es`. Over 600 ISO papers have appeared in the refereed literature since late 1996. An overview of ISO's scientific results, which are impacting all areas of astronomy literally from comets to cosmology, will be given.

FIRST in the context of contemporary facilities such as SOFIA, SIRTF, ALMA….

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FIRST has excellent capabilities for mapping and for high resolution spectroscopy in the heretofore largely unexplored region of the spectrum known as the far-infrared or submillimeter regime. In the wavelength range from about 80 microns to about 600 microns FIRST will have angular resolution as low as 6 arc sec (at 80 microns) and spectral resolution as low as 0.1 km/sec (heterodyne). In L2 orbit, with a passively cooled 3.5 m primary mirror, FIRST will have great sensitivity and an ability for both large area and deep surveying for nearby and distant objects. However, there will be very powerful contemporary instruments also operating in the same, or adjacent wavelength bands. It is important to discuss where these other instruments may compete with FIRST, either over a wavelength range, or for a particular science objective, and equally to find where FIRST is unique, or where it can perform a complementary function.

Submillimeter Wave Astronomy Satellite:
I. Observational Performance and Lessons Learned

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The Submillimeter Wave Astronomy Satellite (SWAS), launched in 1998, is a NASA mission dedicated to the study of star formation and molecular cloud composition through the use of high spectral resolution heterodyne observations of low-lying transitions of water, isotopic water, molecular oxygen, isotopic carbon monoxide, and atomic carbon. To date, the mission has proceeded exceptionally smoothly. During this time, SWAS has demonstrated its ability to map large areas as well as to obtain spectra with r.m.s. baseline noises as low as a few mK. This contribution will review several key instrument performance parameters relating to the detection of weak lines, such as radiometer stability and understanding the nature of the spectral noise, as well as those requirements imposed by the need to fully interpret absorption features, such as knowledge of dust continuum levels and receiver sideband ratios. We will also review some of the observational lessons learned. In particular, we will discuss several important results of the SWAS observations as they apply to the spatial extent of water, atomic carbon, and isotopic carbon monoxide emission and the requirements these measurements will place on FIRST's need to obtain reference positions devoid of line radiation. Finally, we will review the advantages, realized on SWAS, of flexibly scheduling observations and their follow up.

The ASTRO-F survey as inputs for the FIRST

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ASTRO-F is the first Japanese satellite dedicated for infrared astronomy, and will be launched into a sun-synchronous polar orbit by the Japanese M-V rocket in February 2004. ASTRO-F has a cooled 70 cm telescope with two focal plane instruments: one is the Far-Infrared Surveyor (FIS) and the other is the Infrared Camera (IRC).
The prime purpose of the FIS is to perform an all-sky survey with 4 photometric bands in wavelength of 50 - 200 μm. The big advantages of the FIS survey over the IRAS survey are (1) higher spatial resolution ($30''$ at 50-110 μm and $50''$ at 110-200 μm) and (2) better sensitivity by one to two orders of magnitude. The FIS survey will provide next generation far-infrared survey catalogs, which will be ideal inputs for follow-up observations by FIRST.
The other instrument, IRC, will make imaging and low-resolution spectroscopic observations in the spectral range of 2-26 μm. It will make deep photometric and spectroscopic surveys for wide areas of the sky with its wide field of view ($10' \times 10'$). The IRC survey will be complementary with the FIRST observations at longer wavelengths.
We have just started the discussion with ESA on possible collaboration concerning the data analysis activity and supports of tracking stations for ASTRO-F, and some fraction of observing time is expected to be open for European community.

The IR background and potential FIRST and Planck synergies

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Session 4
A Taster of FIRST Science

Deep Surveys and Source Counts

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Models for source counts and background radiation from the submillimetre to the optical are reviewed and compared with source-count data from existing surveys. Predictions are presented for future far infared and submillimetre surveys with SIRTF, Astro-F, Planck and FIRST.

The Earliest Stages of Star Formation: Protostars and Dense Cores

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Despite some progress, both the earliest stages of protostellar collapse and the origin of the stellar initial mass function (IMF) remain poorly understood. Recent 0.85-3 mm surveys of nearby clouds with, e.g., IRAM and JCMT have revealed pre-stellar condensations/cores that seem to be the direct progenitors of individual stars: their mass spectrum resembles the stellar IMF and some of them show spectroscopic evidence of collapse. These ground-based results are very encouraging as they suggest that the IMF is at least partly determined by cloud fragmentation. Since pre-stellar condensations and young protostars have Tbol < 30 K and emit the bulk of their luminosity between ~ 80 and ~ 350 microns, it is nevertheless clear that a large space telescope such as FIRST is needed to make further advances in this area. In particular, FIRST will provide a unique probe of the energy budget and temperature structure of pre/proto-stellar condensations. With an angular resolution at 85-300 microns comparable to, or better than, the largest ground-based millimeter radiotelescopes, the two imaging instruments of FIRST, SPIRE and PACS, will make possible much deeper surveys for such condensations in all the nearby (d < 1 kpc) cloud complexes of the Galaxy. These surveys are already considered among the top scientific priorities of the SPIRE and PACS core observing programmes. They will greatly help develop a satisfactory theory for the origin of the IMF. Follow-up spectroscopy at high resolution with the HIFI instrument will give quantitative constraints on the dynamical and chemical states of the most interesting condensations identified in the photometric surveys.

Comets and asteroids with FIRST

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The promise of FIRST for the study of comets and asteroids will be reviewed. This review will be focussed on: i) observations of water submillimeter lines in comets to measure water outgassing from the nucleus, to study water excitation in the cometary atmosphere and its kinematics, and to measure the ortho-to-para ratio; ii) the major outcome expected concerning solar nebula models and cometary formation with the measure of the D/H ratio in H_2O in a large sample of comets, including short-period comets; iii) the study of surface properties of asteroids.

Session 5
Extragalactic Surveys & Star Formation

Surveys

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Great progress has been made and will continue to be made in surveying the sky at multiple wavelengths. Many new discoveries will be made by combining data in multiple bands. Current surveys include the DPOSS, 2MASS and SDSS, while future surveys include the GALEX AIS in the ultraviolet and IRIS in the far infrared. The proposed PRIME and NGSS surveys would fill in the gap between the near and far infrared.

Edward L. (Ned) Wright, Professor of Physics and Astronomy On sabbatical through June 2001 at the Institute for Advanced Study 609-734-8153 Fax:609-951-4402 wright@astro.ucla.edu ewright@ias.edu

Quasars, Starbursts, and the Cosmic Energy Budget

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I will review the properties of AGN, their relation to starbursts, and how observations with FIRST can make an impact. Observations in the Far Infrared are the best way to make an unbiased survey of active galaxies in the loosest sense, but separating the true quasars from the surrounding starburst may prove difficult. There is in fact much evidence to suggest that starburst and AGN activity are intimately connected, and FIRST will help us explore this link. Since the last major FIRST conference in Grenoble, this issue has become even more central to modern astrophysics, with the realisation of the dominance of the FIR background, the discovery of high redshift SCUBA sources, and the emergence of the black hole mass deficit problem. What dominates the cosmic energy budget - nuclear fusion or accretion ?

Outflow dynamics, accretion disks and chemical abundances

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FIRST is ideally suited for studying the earliest stages of star formation. Wide-field SPIRE and PACS imaging surveys will allow us to complete the census of protostars in the nearby molecular clouds. Spectroscopic studies of these protostars will provide important information to constrain the physical processes that are taking place in these protostars.

The excitation near young stellar objects is dominated by a mixture of photodissociation regions (PDRs) and shocks. While shocks are expected to be the dominant excitation mechanism in bipolar outflows, PDRs are expected to be important in the inner envelope and the accretion disks. To distinguish between regions dominated by shocks and PDRs is essential for the correct interpretation of the data. We can distinguish between PDRs and shocks by (i) determining the excitation conditions of the dominant coolants; (ii) chemical arguments, a different chemistry is expected in shocks and PDRs; (iii) the kinematical structure of the region, since the molecular emission occurs in the post-shock accelerated gas, the lines may be shifted appreciably from the velocity of the ambient gas; and (iv) energetic arguments, the IR line emission /IR continuum emission ratio is expected to be very different from PDRs to shock. However, very few times these diagnostics have been applied successfully to previous observations. This was mainly because previous observations (mainly ISO) were hampered by the limited sensitivity, the poor angular and spectral resolution (beam = $80''$, Δv = 10 kms^{-1}), and the observation of the high excitation lines (with critical densities larger than 10^6 cm^{-3}). The detailed study of prototypical regions using the high spatial and spectral resolution provided by HIFI will allow to fully characterise the physical and chemical conditions in PDRs and shocks.

Applying these results to other YSOs, we hope to be able to construct a physical and chemical evolutionary sequence in YSOs. Large surveys of young stellar objects of different luminosities and ages, will allow to determine the dependence of the physical conditions and chemistry of the circumstellar material with the spectral type of the newly formed star.

Molecular Line Surveys of Star-Forming Regions with FIRST

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The principal scientific drivers for high resolution spectroscopic line surveys of star-forming regions with FIRST are reviewed. Recent ground-based surveys at lower submillimeter frequencies have revealed remarkable physical and chemical variations between different objects which are likely related to their evolutionary state. The importance of complementary high-frequency data with HIFI will be discussed. Surveys provide a near-complete census of the gas-phase abundances, which can be compared with solid-state abundances derived from mid-infrared observations. The power of surveys at THz frequencies will be illustrated through examples of spectral scans obtained with the ISO-LWS, and prospects for further studies with PACS will be emphasized. Finally, the possibilities for surveying circumstellar disks will be mentioned.

Session 6a
Extragalactic Surveys

Deep Surveys with FIRST and Cosmology: A Revised Case

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The ESA/FIRST mission, the *first* 4-m class observatory in space, will allow drastic improvements in mapping for faint sources with respect to previous far-IR telescopes, and will provide complementary spectral coverage with respect to major projects like NGST and ALMA. FIRST will be the most powerful tool to investigate crucial phases in the evolution of galaxies at long wavelengths, whose relevance has only recently been fully understood.

The present contribution is aimed at reviewing the scientific case for deep cosmological surveys that will be performed with FIRST, in the light of recent discoveries by the Cosmic Background Explorer, the Infrared Space Observatory and large millimetric telescopes on ground. All these have shown that crucial phases in galaxy formation and evolution at high-redshifts can be only investigated at long wavelengths, in particular phases of enhanced activity of star formation, consequent to merging, bringing to the formation of galaxy spheroids.

FIRST will be the only planned instrument for many years to come working in the far-IR with imaging capabilities comparable to those of optical telescopes on ground, able to accurately measure the bolometric emission of galaxies and active nuclei at any redshifts.

Simulations of the Infrared Sky

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One of the main tasks of FIRST is to carry out shallow and deep surveys in the far-IR / submm spectral domain with unprecedented sensitivity. Selecting unbiased samples out of deep surveys will be crucial to disclose the entire history of evolving dusty objects, and therefore of the star-formation.

However, the usual procedures to extract information from a survey, i.e. selection of sources, computing the number counts, the luminosity and the correlation functions, and so on, cannot lead to a fully satisfactory and rigorous determination of the source characteristics. To check the reliability of the obtained results the simulation, via Monte Carlo techniques, of a large number of mock surveys is mandatory. This provides information on the observational biases and instrumental effects introduced by the observing procedures and allow to understand how the different parameters affect the source observation and detection.

We present here the first results of a project aiming at developing the tools to simulate the extragalactic far-IR/submm sky as PACS (and SPIRE) will see, to build up complete mock catalogues, to single out high-z candidates in colour-colour diagrammes and to construct a photometric redshift catalogue.
This latter allows to understand how redshifts are extracted from the used photometric bands and how photometric errors affect the selection of high-redshift 'candidates' from colour-colour plots.

Extra-Galactic Field Surveys with FIRST: Practical Considerations

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We discuss some of the practical considerations that need to be made in the design of extra-galactic field surveys using FIRST. In particular we discuss the factors that need to be taken into account in selecting the survey fields. The final choice of fields will be influenced by the location of other surveys that are currently being planned; so it is vital that the FIRST community begin debating this issue now. We consider the possible sizes and depths of survey fields and the merits of covering fields at both PACS and SPIRE wavelengths in order to meet many of the scientific objectives of the FIRST mission. Finally we investigate the various limitations that confusion noise imposes on possible FIRST surveys and the benefits of super resolution techniques.

Optical and near-IR follow-up of the European Large Area ISO Survey

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One of the key scientific objectives of FIRST is to study extragalactic populations at high redshift by deep extragalactic photometric surveys followed by spectroscopy of selected sources. The Infrared Space Observatory has started, at shorter wavelengths, these studies with several extragalactic surveys. ELAIS (European Large Area ISO Survey) is a project that has surveyed about 13 square degrees of sky using both ISOCAM and ISOPHOT. Observations at 6.7, 15, 90 and 175 μm have been obtained. These observations together with the extensive followup programs carried out in these regions have made the ELAIS fields excellent areas for multi-wavelength observations and for future surveys with FIRST. These include radio observations using VLA, optical and near-IR, sub-mm and X-rays using Chandra and XMM. We report here the results of our imaging and spectroscopic observations carried out with telescopes at the Observatorio del Roque de los Muchachos in La Palma in 2000 within the International Time Project to follow-up the ELAIS survey. More than 200 redshifts of ELAIS galaxies have been obtained. A comparison will be made with results from other, deeper, surveys over smaller areas and preliminary results on the multiwavelength SEDs of ELAIS sources will be presented.

The 170 μm Serendipity Survey

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The ISOPHOT Serendipity Survey utilized the otherwise unused slew time between ISO's pointed observations with strip scanning measurements of the sky at 170 um. During ISO's lifetime, nearly 550 hours of observing time were collected, leading to an incomplete sky survey with a coverage of ~ 15%. The ISOPHOT Serendipity Survey is the only large scale sky survey long-ward of the IRAS 100 um wavelength limit to date.

The first list of 115 point sources associated with catalogued galaxies indicated that a large fraction of galaxies have a spectral energy distribution rising beyond 100 um, indicating a cold (14K < T < 20K) dust component. This increases the derived dust masses by a factor 2 - 10, and leads to gas-to-dust ratios much closer to the canonical value for the Milky Way. A number of low-luminosity galaxies also have a high 170 um / 100 um flux ratio, indicating a very cold dust component (T < 15K) and thus only very low-level star formation activity. Results of ground-based follow-up observations to investigate the nature of these cold galaxies will be reported. A much larger galaxy catalogue of ~ 1000 sources is being prepared.

A similar Serendipity Slew Survey with FIRST/PACS is currently being discussed in the PACS consortium. If technically feasible, it would increase tremendously the number of sources observed with an angular resolution necessary to allow an unambiguous identification at other wavelengths. Furthermore, it would avoid the "knowledge bias" of observatory telescopes, and has thus the potential of detecting hitherto unknown FIR emitters.

Session 6b
Star Formation

Physics of High-Mass Star Formation - Contributions from PACS

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The formation of massive stars plays a major role in structuring galaxies and determining their chemical and dynamical state. In contrast to this fact, we presently do not know if such stars form by the accretion process or the coalescence of intermediate-mass protostellar clumps. We will discuss how the PACS instrument can contribute to the determination of the (proto)stellar content of high-mass star-forming regions - a necessary information we need for the evaluation of the coalescence scenario. Complete line surveys with PACS will lead to a better understanding of the cooling mechanisms of quiescent molecular cloud cores, Hot Cores, and PDRs. The temperature of the star-forming regions is a key parameter for the accretion process.

Star formation in clusters: from ISO to FIRST

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The gain in imaging capability and spectral resolution of FIRST, compared to ISO, will result in a substantial progress for the study of star formation and, in particular, of star formation in clusters.

FIRST, with its relatively high spatial resolution at the frequency where protostars peak, will be the best available tool for detecting and studying young clusters and proto-clusters with a sensitivity 2 orders of magnitude better than present ground based facilities.

The spectroscopic imaging capability of FIRST will give a full spectrum for each spatially resolved element in a F.O.V. of several arcmin, tracing temperature, densitiy and chemical composition of the interstellar gas. Moreover, the high resolution spectroscopy will study the dynamics. These observations will allow to study the physical processes going on (outflows, shocks, ionising fields,…) and trace in the interstellar gas the interactions among the members of a cluster.

A 350 microns Study of Massive Star Formation Regions

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and
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Abstract: We will present 350 microns images of the dust continuum in massive star formation regions obtained with the Caltech Submillimeter Observatory equipped with the SHARC focal-plane bolometre array. Results will be shown for Galactic compact HII regions and for the giant HII region NGC604 in M33. For the Galactic regions, we have obtained maps for 24 regions and identified 28 separate 350 microns components. Ten of the 28 components do not have radio continuum counterparts and are postulated to be the precursors to ultracompact HII regions and should have the properties of accreting massive protostars. Futher observational studies of these sources should be done. We will discuss the relevance of these findings for the Galactic surveys planned with FIRST as well as for their study with the spectral and spectro-imaging capabilities of FIRST. Finally, we will present a 350 microns map of NGC604 and compare the dust emission in this giant HII regions with other tracers such as HI, Halpha and CO.

Protoclusters and the Formation of Massive Stars

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We have completed a systematic search for intermediate and high-mass protostellar objects in the northern and part of the southern sky. A homogeneous database exists, containing high spatial resolution line and continuum imaging from 1 μm to 3.6 cm for the most promising candidates of the sample.

We investigate modes and time scales for star formation in these systems. Clustering is present at all wavelengths, indicating clump fragmentation early on in the formation process, and we discuss the implications for the formation of massive objects in the accretion-*vs*-coalescence framework. We also discuss the potential impact of the FIRST mission for our understanding of the formation of protoclusters and massive stars.

The study of protostellar outflows with FIRST

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With the present contribution we would like to overview the capabilities offered by the three instruments on-board FIRST for the study of outflows from young stellar objects.
Bipolar outflows are one of the first observational manifestations of the formation of a new star; the study of their properties can be therefore a powerful tool to derive information on the embedded exciting source which is often much more difficult to be directly observed. Outflows drive strong radiative shocks whose cooling occur over a wide range of wavelength from the UV to the submillimeter. The frequency range covered by FIRST, however, contains the most basic information on the physics and chemistry of the molecular gas at the excitation conditions attained in shocks. The importance of observations in the far infrared for the study of outflows has been demonstrated by the results obtained with ISO on a relatively large sample of young stellar objects; their far infrared spectra are dominated by strong lines of [OI], CO, H_2O and OH, which constitute a significant fraction of the total shock gas cooling. An analysis of such emission shows however that ISO is too limited in terms of spectral coverage, sensitivity, spectral and spatial resolution to allow for more than gross estimates of the physical parameters of the gas emission averaged over the beam. On the basis of what we have learned with ISO, we will discuss the potentiality of FIRST to make a detailed analysis of the chemical and physical structure of the bipolar outflows and to trace its evolution during the protostar lifetime.

Probing the center of the canonical YSO L1551 IRS 5 – what we have learned from ISO, and the implications for FIRST science

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Spectroscopic observations using the Infrared Space Observatory are reported towards the two well known infrared sources and young stellar objects L1551 IRS 5 and L1551 ,NE, and at a number of locations in the molecular outflow. The ISO spectrum contains several weak gas-phase lines of OI, CII, [Fe,II] and [SiII], along with solid state absorption lines of CO, CO_2, H_2O, CH_4 and CH_3OH. Hubble Space Telescope (HST) images with the NICMOS infrared camera reveal a diffuse conical shaped nebulosity, due to scattered light from the central object, with a jet emanating from L1551 IRS 5. The continuum spectral energy distribution has been modelled using a 2D radiative transfer model, and fitted for a central source luminosity of 45 solar luminosities, surrounding a dense torus extending to a distance of ~ 3 10^4 AU, which has a total mass of ~ 13 solar masses. The visual extinction along the outflow is estimated to be ~ 10 and the mid-plane optical depth to L1551 IRS 5 to be ~ 120.

This model provides a good fit to the ISO spectral data, as well as to the spatial structures visible on archival HST/NICMOS data, mid-IR maps and sub-millimetre radio interferometry, and to ground-based photometry obtained with a range of different aperture sizes. On the basis of the above model, the extinction curve shows that emission at wavelengths shorter than ~ 2 µm is due to scattered light from close to L1551 IRS 5, while at wavelengths > 4 µm, is seen through the full extinguishing column towards the central source. Several [FeII] lines were detected in the SWS spectrum towards L1551 IRS 5. Although it would seem at first sight that shocks would be the most likely source of excitation for the [FeII] in a known shocked region such as this, the line intensities do not fit the predictions of simple shock models. An alternative explanation has been examined where the [FeII] gas is excited in hot (~ 4000 K) and dense (> 10^9 cm^{-3}) material located close to the root of the outflow. The SWS observations did not detect any emission from rotationally excited H_2. Observations with United Kingdom Infrared Telescope (UKIRT) of the vibrationally excited *S*- and *Q*-branch lines were however consistent with the gas having an excitation temperature of ~ 2500 K. There was no evidence of lower temperature (~ 500 K) H_2 gas which might be visible in the rotational lines. Observations with UKIRT of the CO absorption bands close to 2.4 µm are best fit with gas temperatures ~ 2500 K, and a column density ~ 6 10^{20} cm^{-2}. There is strong circumstantial evidence for the presence of dense (coronal and higher densities) and hot gas (at least 2500 K up to perhaps 5000 K) close to the protostar. However there is no obvious physical interpretation fitting all the data which can explain this.

The paper will attempt to draw together data from the complete wavelength coverage available from space and the ground, and summarise this in terms of what we might expect to learn from sources like this, that will be useful in planning the science programme for FIRST.

Session 7
Far & Near

Chemical Abundances over Cosmic Time

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The last few years have seen major advances in the study of chemical abundances at high redshifts. It is now possible to measure directly the degree of enrichment of several elements in a variety of environments up to redshift $z = 5$, probing conditions only 1-2 Gyr after the Big-Bang. In my review I shall summarise the latest observations of Lyman break galaxies, damped Lyman alpha systems and the Lyman alpha forest with a view to uncovering the clues which these data offer to the first episodes of star formation in the universe. I shall emphasise the limitations, as well as the merits, of the techniques which have been exploited up to now, and look forward to the impact of the FIRST mission on this whole area of work.

Observations of planet and satellite atmospheres and surfaces with FIRST

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The exploration of the submillimeter range by FIRST will open new prospects for the study of planetary and satellite atmospheres and surfaces. Four main themes can be envisaged. (i) new measurements of the abundances of deuterium and helium in the atmospheres of the Giant Planets will provide improved constraints on their origin and evolution (ii) the observation of water in the upper atmospheres of the Giant Planets and Titan will give further insight in the source of external water in the Outer Solar System (iii) the search for new atmospheric compounds will improve our understanding of chemical and physical phenomena governing atmospheric composition. Significant progress, in particular, in expected on the tropospheric composition of the Giant Planets and on the martian photochemistry (iv) the photometric, thermal and compositional properties of planetary and satellite surfaces (Mars, Giant Planet satellites, Pluto/Charon, some bright TNOs). Current knowledge on these aspects will be reviewed and the expected promise of FIRST discussed.

Session 9

Galaxies & Stars

Spectroscopy of ultraluminous and interacting galaxies

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The potential of mid- and far-infrared spectroscopy for quantitative studies of starburst and active galaxies, and for uncovering the power sources of obscured ultraluminous galaxies, has for the first time been demonstrated by the ISO mission.
I will report on the results of infrared spectroscopy of star forming galaxies, AGN, and ultraluminous infrared galaxies, and extrapolate on how spectroscopy with FIRST will be able to advance our knowledge of these objects both locally and at higher redshifts.

The Promise of FIRST Studies of Normal and Dwarf Galaxies

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I will review what we know about normal and dwarf galaxies, with an emphasis on the contributions of IRAS and ISO observations to our understanding of the interstellar medium, galactic nuclei, and evolution of these galaxies. I will discuss open questions about the evolution of galaxies and the promise of FIRST and its place among other new observatories in helping to answer these questions because of its increased spatial resolution, sensitivity, and far-IR-submillimeter wavelength range compared with ISO and IRAS.

H_2O in interstellar and circumstellar clouds : What we know and what could be expected from FIRST

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I will review the ISO observations of water vapor emission/absorption lines in molecular clouds and circumstellar envelopes in terms of the physical parameters that can be derived from them. H_2O can be an efficient cooler of the regions where its emission is produced and probably plays an important role in the chemistry and dynamical evolution of the warmest zones of molecular clouds. I will discuss the limitations of the data available so far, due to several observational constraints, and the current interpretations of this available information, focusing in particular on Orion, SgrB2 and Sgr A. The role of dust in the excitation of H_2O will be discussed and detailed modeling will be presented (see also the contribution by González-Alfonso).
FIRST will provide much more sensitive observations than ISO and SWAS. The study of interstellar and circumstellar clouds with HIFI using the emission/absorption water lines should allow to resolve the velocity structure and to derive the physical conditions of the innermost zones of massive star forming regions such as Orion. The same applies to the shocked regions produced by the outflows of newly formed low mass stars. PACS and SPIRE will provide simultaneous multi-line intensity information of H_2O in these regions. Although the velocity resolution will be much lower than that provided by HIFI, covering all H_2O lines up to wavenumbers of 150 cm^{-1} ($\lambda \simeq 63$ μm) will permit to study in detail the role of H_2O in the cooling processes of star forming regions and of evolved stars.
The predictions of H_2O line intensities as they could be seen with FIRST detectors towards several molecular clouds and evolved stars will be presented and discussed. In a separate contribution, González-Alfonso will present the radiative transfer models that we have developed in the framework of H_2O studies with FIRST.

Molecular Spectroscopy in AGB star envelopes

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The envelopes expelled by AGB stars play a crucial role in the regeneration of the interstellar medium and its enrichment in heavy elements and grains. These envelopes are also the sites of formation of a large variety of molecules, which range from acetylenic chains to metal-bearing radicals. Because of this wealth of interstellar-type molecules, and because the physical conditions and time-scales in the envelopes are well known, AGB stars stand out as unique laboratories for the study of astrochemical processes.

Two-thirds of the known interstellar molecules are observed in the envelopes of AGB stars. Most of them were found by surveying the mm-wave spectra of the nearby C-rich envelopes IRC+10216, CRL 618, and CRL 2688. The number of reactive species in these envelopes is stunning; as a matter of fact, many radicals have been discovered in IRC+10216, the closest of these stars, prior to be observed in a spectroscopic laboratory. MM-wave observations, however, are sensitive only to polar molecules, and our knowledge of the envelope chemical composition is partial. ISO, which has recently surveyed the infrared spectra of these objects, has greatly contributed to correct this bias by revealing the presence of polyacetylenes, and, even, of benzene. These latter species are not observed in IRC+10216, but in CRL 618, a more evolved object. The presence of benzene in CRL 618 may yield clues to the formation of PAHs and small graphitic grains in the diffuse, unshielded envelopes surrounding planetary nebulae.

HIFI/FIRST, which will bridge the frequency gaps left by ISO/LWS and ground-based submm observations, will yield the first complete high resolution spectra of these objects. At the longest wavelengths surveyed by ISO, it will also provide an important gain in sensitivity and spectral resolution. Of special interest will be the access to the rotational lines of new, light molecules, such as the simple hydides, and the study of the shapes of high excitation lines, which trace the dust and wind formation regions.

Session 10a

Galaxies & Galaxy Clusters

FIRST/PLANCK synergies on clusters of galaxies

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The Early Compact Source Catalog produced from the first 6 months of the PLANCK mission will contain thousands of clusters of galaxies identified from their Sunyaev Zel'dovich imprint on the Cosmic Microwave Background. Among them, about one half will be previously unknown very distant clusters, $z > 0.2$, spatially unresolved (the exact proportion depending on the actual geometry of the Universe). An immediate follow-up of a subset of these clusters with the FIRST bolometric cameras (SPIRE) will be highly profitable and has to be prepared in advance. With two pointings of the telescope and a short integration time (a few minutes) we will be able to cover the area of the PLANCK beam for each cluster with a sensitivity better than the confusion limit imposed by the field infrared galaxies. This will allow to : 1/ identify the field IR galaxies to improve the S.Z. / dust separation in the cluster direction and allow the determination of the cluster physical parameters (T_e, V_p, M_{tot}, baryon fraction), 2/ identity and study the star formation within the cluster, 3/ Spatially resolve the S.Z. profile of the cluster. We will present detailed simulations of FIRST and PLANCK observations of clusters of galaxies, pointing out the unique science that will emerge from this synergy.

Dust in PG quasars as seen by ISO

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Is every PG quasar accompanied by considerable amounts of dust? Or do also relatively dust-free, naked quasars exist which might be more evolved? Is the AGN the sole power source in dusty PG quasars or do starbursts play a significant role?

What is the relation between PG quasars and ultraluminous IR galaxies? What are the edge-on counterparts of dusty PG quasars? Why could also ULIRGs with cool MIR/FIR colors house a PG quasar?

Topics like those above are addressed on the basis of sensitive near- to far-infrared photometry with the Infrared Space Observatory ISO, and further aspects for FIRST are presented.

Stellar and Gas Dynamics in Ultraluminous Mergers

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A significant new element in the exploration of high-z star formation has recently emerged with the COBE detection of an extragalactic submm background. Its energy density is at least as large as that of the combined light of all galaxies emitting in the optical/UV, and it appears to be dominated by very luminous ($>10^{12}$ $L_\odot$) galaxies at z>1. It is likely, therefore, that very luminous dusty starbursts contribute significantly to the cosmic star formation rate at z>1. FIRST will resolve the sources comprising the submm background, and determine the statistical nature of these galaxies. Very high resolution detailed spectroscopy of individual sources will be crucial to determine their evolutionary states and their dynamical masses. We report here on VLT and Keck H- and K-band spectroscopy of the local analogs of this high-z population: the ultraluminous infrared galaxies (ULIRGS). The sources in our sample are all in a moderately advanced state of merging. We find that their stellar dynamics are relatively relaxed, and that the merger remnants have velocity dispersions comparable to those of elliptical galaxies. For those sources with well-separated nuclei, we observe rotation in the individual nuclei, indicating that they are still dynamically independent. We will put our observations in the context of the evolutionary scenario where ULIRGs may evolve into ellipticals through merger induced dissipative collapse, perhaps passing through a QSO phase on their way.

Far-infrared energy distributions of active galaxies in the local universe and beyond: From ISO to FIRST

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The results of the ISO photometric surveys of both the 12 micron active galaxy sample (in the local universe) and of an optically selected quasar sample with an average redshift of z = 1.4 are reviewed.

We will discuss what the FIRST camera arrays will be able to achieve and how will contribute in understanding the nature of activity in galaxies. These will be especially due to the improved sensitivity and spatial resolution over ISO and the spectral coverage extending to longer wavelengths.

The selection of unbiased samples of active galaxies will allow us to trace back their evolution and the relation between activity and star-formation in the Universe.
The spectroscopical follow-up with PACS will provide a unique tool to unveil the properties of the environment of the central source and the dominant emission mechanism.

Mid-FIR properties of ELAIS sources

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ELAIS consortium

The European Large Area ISO Survey (ELAIS) was the largest single Open Time project conducted by ISO. It mapped an area of 12 square degrees at 15μ with ISO-CAM and at 90μ with ISO-PHOT, together with a coverage of 6 and 1 square degrees at 6.7μ and 175μ, respectively. One of the main goals of the project was to be able to obtain greater understanding of the cosmological history of star formation, since ISO allowed to detect galaxies with high rates of star formation at much higher redshifts than IRAS.
We present the properties of all the galaxies detected by ISO at 7, 15 and 90μ in ELAIS northern fields. The spectral energy distribution (SED) of those 20 galaxies with IRAS detections can generally be well fitted by a predominant cirrus component plus a modest starburst contribution. For galaxies with higher $f_{15}/f_{6.7}$, a substabtial starburst is required. Follow-up spectroscopy has shown that all the objects are emission-line galaxies but without a very intense star formation event. Most of the galaxies analyzed by means of optical R band photometry result to host an important exponential disk component, in good agreement with the SED IR modelling. We note that galaxies with morphological signs of perturbations seem to show higher $f_{15}/f_{6.7}$ ratios, indicating that star formation is more
important in them. One of the objects is a broad-line, radio-quiet quasar at z=1.099; its spectral energy distribution indicates that it is a hyperluminous infrared galaxy (HLIG), the first HLIG detected in the ELAIS areas.

Mid-IR properties of normal spirals – questions for the Far-IR

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We have assembled a sample of 70 spiral galaxies observed with ISOCAM at 7 and 15 microns, with the aim to investigate the links between the mid-IR emission, star-formation, morphological type, and bar type.

We show that global MIR disk fluxes are linearly correlated with Halpha, implying that in the disk, the MIR emission can be used as a reliable star formation tracer. We also show that the nuclear regions introduce a non-linearity to that relation, possibly due to a different mode of star formation (nuclear starburst) or to a higher extinction. We postulate that the well-known non-linearity of the FIR-Halpha correlation is also due to the contribution of the central regions, a fact that FIRST is well suited to investigate.

We show that the MIR-correlation breaks down when investigating individual regions inside galaxies, only to reappear when the scales considered reach 1-2 kpc. This indicates that ionizing and non-ionizing photons can have very different and very large mean free paths in the disk of galaxies. It also points to the difficulty of identifying the heating sources for the dust based simply on positional association between dust clouds and stars and favors a methodology where energy budgets are used.

Finally we investigate the impact of a bar on the mid-IR properties of spirals and show that this generally leads to a central starburst in early-type spirals only. This study shows that the state of star formation can be very different in the disk and in the central regions of spiral galaxies. Yet current instruments are not able to spatially resolve these two components in the FIR, resulting in much confusion in our understanding of the impact of star formation on the FIR emitting dust.

Session 10b
Evolved Stars & Dust: Part 1

The promise for AGB stars: The physics/chemistry of the inner circumstellar envelope, and the mass loss history

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Physics/chemistry of the inner envelope
The PACS imaging line spectrometer will provide important information on the physical/chemical conditions in the inner circumstellar envelopes of AGB-stars, e.g. on the rotational transitions of the important coolants CO, HCN, and H_2O, and on various molecular species that participate in the initial chemistry of the escaping gas. ISO was limited to high mass loss rate and/or very nearby objects. In addition studies of the dynamics in the acceleration zone will be possible with HIFI.

Dust composition
Most of the solid state features are found in the NIR and MIR ranges, although a crystalline water ice feature at $62\,\mu$m has been seen towards early post-AGB objects, planetary nebulae, Herbig Ae/Be stars, and Herbig-Haro objects. Most ISO observations in these ranges were suffering from too low S/N-ratios. The sensitivity of FIRST is superior, but the short wavelength end of PACS may limit what can be achieved in this area.

Long-term evolution of the AGB mass loss
The temporal variation of the mass loss rate is to a large extent unknown. This applies to all time scales from the pulsation period to the full time scale of the AGB-phase. On the intermediate time scales (10^2–10^4 yr) there is now growing evidence for substantial variations in the mass loss rate, e.g. detached CO and dust shells and multiple-shell structures seen in scattered light. Extended dust emission observed with PACS, perhaps in combination with SPIRE, will provide important results on the long-term mass loss history.

Evolution of Carbon-rich Proto-Planetary Objects

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Abstract:

The circumstellar envelopes of evolved stars are important objects for the stellar evolution. As proved by ISO, these objects are very good targets for FIRST (large quantity of dust, molecules...). and it will fill the gap between the mm and ISO. HIFI will allow the study of the inner layers where dust and wind formation occur, to trace shocks, to study the intern photodissociation (PDR), and more especially the mass loss history. HIFI will provide informations about the velocity structure of the envelopes. Black-bodies with temperatures between 10 K and 50 K peak in this wavelength range. Gases with temperatures between 10 K and a few hundred K emit their brightest molecular and atomic emission lines here. The observation of new transitions of H_2O and CO with a high velocity resolution will allow the study of the circumstellar envelopes at intermediate temperatures. Naturally new molecular emissions will be discovered, and fine-structure lines will be observed, as low-lying ro-vibrational transitions of complex species such as PAHs. We will present an example of what ISO teached us about the transition of an AGB star to the PN stage. We compare ISO LWS observations of three C-rich objects typical of each step of the fast transition of an AGB star to the Planetay Nebula stage: CRL 2688, a very young Proto-Planetary Nebula, CRL 618 a Proto-Planetary Nebula, and NGC 7027 a young Planetary Nebula. We underline the violent changes that occur in the chemical composition of these objects due to the increasing UV radiation field and the strong shocks generated by fast stellar winds. The importance of these mechanisms depends on the degree of evolution of the star. This is clearly indicated by the atomic and ionic fine-structure lines appearing in CRL 618, and predominant in the spectrum of NGC 7027. On the other hand, shocks are less important as the evolution goes on. We confirm that O-bearing species other than CO are produced in the innermost region of the circumstellar envelope: the UV photons from the central star photodissociate most of the molecular species produced in the AGB phase and allow a chemistry dominated by standard ion-neutral reactions. Indeed, in CRL 618 H_2O and OH appear; CO molecules are reprocessed. HCN molecules are also reprocessed, leading to strong HNC emission close to the PDR. At this point, CO lines and [OI] atomic lines are the dominant coolants. As the star reaches the PN stage, all the old AGB material has been reprocessed: the CO and other molecules are constantly produced and destroyed. The spectra is now dominated by atomic and ionic lines. New species appear like CH^+; the abundance of OH has increased. There is only weak HCN, and quite no water detected. H_2O has then probably been reprocessed and is only an intermediate molecule of the Proto-Planetary Nebula stage.

Excitation and dynamics of the gas in planetary and proto-planetary nebulae: Optical, IR, and mm-wave data

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Most of the material in planetary and proto planetary nebulae (PNe, PPNe) is been accelerated and excited by shock fronts, produced by the interaction between the slow but dense AGB wind and post-AGB ejections, diffuse but very fast and collimated. The molecular component, probed by mm and sub-mm wavelengths, is often very massive and represents the bulk of the nebular material. A good deal of this gas has been strongly accelerated by the shocks, although it has cooled down to very low temperatures, 10 – 30 K. (These structures are also observed by means of scattered light in the visible.) There is also a high-excitation component, with representative temperatures larger than 1000 K, observed by means of interaction between the slow but dense AGB wind and post-AGB ejections, diffuse but very fast and collimated. The molecular component, probed by mm and sub-mm wavelengths, is often very massive and represents the bulk of the nebular material. A good deal of this gas has been strongly accelerated by the shocks, although it has cooled down to very low temperatures, 10 – 30 K. (These structures are also observed by means of scattered light in the visible.) There is also a high-excitation component, with representative temperatures larger than 1000 K, observed by means of optical and NIR lines. Such a gas seems to correspond to clumps in the post-AGB jets excited by counter-shocks.

The description of the excitation state of the nebula needs information on the intermediate states, based on observations at intermediate frequencies. In particular, we have not identified the (forward) regions in which the dense gas is been accelerated, which is the main dynamical phenomenon in the shaping of PNe. ISO has observed fine-structure atomic lines, from gas at typically a few hundred K. However, a good spectral resolution, as that provided by HIFI/FIRST, is needed to conclude on the kinematics of this component. Such an information is also useful to discern between gas excited by stellar photons (PDRs) and shocked regions.

ISO Observations of Atomic Fine-Structure Lines From Proto-Planetary Nebulae

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We present ISO observations of atomic fine-structure lines in the far-infrared (FIR) from protoplanetary nebulae (PPNe). The sample is composed of 24 sources, mostly PPNe but also including a few planetary nebulae and AGB stars for comparison. Data on FIR lines of O^0, C^+, N^+, Si^0, Si^+, S^0, Fe^0, and Fe^+ were obtained. PPNe are found to emit in these low-excitation atomic transitions only when the central star is hotter than ~10000 K. This result suggests that such lines predominantly arise from Photo-Dissociation Regions (PDRs). Our results are also in reasonable agreement with predictions from PDR emission models, allowing the estimation of the density of the emitting layers from comparison with the model parameters. However, Fabry-Perot ISO observations suggest in some cases a contribution from shocked regions, in spite of their poor sensitivity and spectral resolution. The intensity of the line [C II] 158 μm has been used to measure the amount of low-excitation atomic mass in PPNe, since this transition has been found to be a useful model-independent probe to estimate the total mass of this atomic gas.

Radiative transfer in molecular lines

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Since Berner (1979), most of the RT codes for molecular lines have used numerical strategies based on a combination of Montecarlo techniques and the Λ-iteration method to obtain non-LTE level populations. More recently, some efforts have been dedicated to improve the poor convergence rate of this type of schemes. Thus, Accelerated Lambda Iteration (ALI) methods have recently started to be applied to molecular radiative transfer.
Very recently, extra efforts in the fields of Stellar Atmospheres and of Solar and Stellar Physics have led to the development of novel RT tools. These new developments have made it possible the numerical solution of complex RT multilevel problems (in 1D, 2D and 3D) for both unpolarized and polarized radiation. As shown by us in a previous contribution at this conference these novel RT methods are based on iterative schemes that allow the solution of a given RT problem with an order of magnitude of improvement in the total computational work with respect to the standard ALI method (see also Trujillo Bueno and Fabiani Bendicho, ApJ, 1995).
In this contribution we present the generalization of such efficient RT tools to the case of RT in molecular lines in stellar spherical envelopes with macroscopic velocity fields. Our motivation is to develop a number of powerful RT tools and to apply them with the aim of planning and interpreting future observations with FIRST. As a first application we show some preliminary results of non-LTE RT simulations in the CO molecule that are helping us to interpret observations of the fundamental tone at 4.6 μm of the oxygen-rich star VYCMa.

Very Fast Iterative Methods for Radiative Transfer Applications

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The development of novel Radiative Transfer (RT) methods often leads to important breakthroughs in astrophysical plasma spectroscopy, because they allow the investigation of problems that could not be properly tackled using the methods previously available. This RT topic is also of great interest for the "Promise of FIRST" because a rigorous interpretation of the observations will require to carry out detailed confrontations with the results from Non-LTE RT simulations in one-, two-, and three-dimensional geometries.
The efficient solution of Non-LTE multilevel RT problems requires the combination of a highly convergent iterative scheme with a very fast formal solver of the RT equation. This applies to the case of unpolarized radiation in atomic lines, to the promising topic of the generation and transfer of polarized radiation in magnetized plasmas and to RT in molecular lines.
The "dream" of numerical RT is to develop iterative methods where everything goes as simply as with the so-called Λ-iteration scheme, but for which the convergence rate is extremely high. In this contribution we will describe novel RT methods based on Gauss-Seidel iteration. These methods are of interest because they allow to solve a given RT problem with an order-of-magnitude of improvement in the total computational work with respect to the standard ALI method. We will show that their convergence rate is very high, that they do NOT require the construction and the inversion of any large matrix and that the computing time per iteration is very small (i.e. similar to that of the $\Lambda-$iteration method). We will show illustrative results for the case of unpolarized radiation in atomic lines (in 1D, 2D and 3D with multilevel atoms) and also for the case of the transfer of polarized radiation in magnetized plasmas. The case of RT in molecular lines will be presented in an extra contribution at this conference by Asensio Ramos, Trujillo Bueno and Cernicharo.

Session 11a

Extragalactic Spectroscopy & C^+

Extragalactic astronomy with HIFI

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We discuss the potential of HIFI for extragalactic spectroscopy, both at low and high redshift, emphasizing frequency ranges that are not easily accessible from the ground. We will highlight three fields:

1) molecular spectroscopy of starburst and ultraluminous galaxies; the interstellar media of such objects are very different from the interstellar medium of the Milky Way. Multi-line spectrscopy will reveal the temperature and density structure of the star forming clouds. The crucial diagnostics probing dense and hot gas are of such high frequency as being inaccessible from the ground.
2) the diffuse medium in nearby galaxies, which can be probed by HIFI in the 158 micron [CII] line
3) the prospects for detecting high-z starburst galaxies with HIFI, principally in the 158 micron [CII] line.

FIR spectroscopic signatures of young galaxies

Sangeeta Malhotra

ISO has enabled us to study FIR spectra of a large variety of galaxies. The properties of actively star-forming galaxies are fairly different from those of metal-poor irregular galaxies. This contrast is seen most dramatically in the strength of the [CII] line: metal-poor, irregular galaxies show stronger than average [CII] but actively star-forming galaxies show [CII] deficiency (Malhotra 1997). Young galaxies are expected to be both metal-poor and actively star-forming, leading to contradictory expectations of the [CII] strength. Other FIR lines can also be used to find/confirm metal-poor starbursts. Using our observations of normal z=0 galaxies and reasonable expectations of high-redshift starbursts, we try to predict the spectral signatures of primitive, high-redshift galaxies.

Heating and Cooling of the ISM in low metallicity environments

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Dwarf galaxies are thought to be important constituents in the hierarchical construction of massive galaxies. Being low in metallicity, they are thought to be at relatively early epochs of chemical evolution, thus, making local dwarfs potential laboratories to study starformation environments in young galaxies. FIRST has the capability to explore the spectral signatures characterizing the nature of dust and gas as a function of galaxy metallicity.

We are studying the effects of metallicity on the heating and cooling processes in the ISM via observations of the MIR to submm dust spectra in conjunction with the important gas cooling line, [CII], at 158 micron. From our survey of dwarf galaxies, we find a profound effect on the observed properties of the gas and dust due to the low metallicity nature of the ISM. For example, we find enhanced I[CII]/I(CO 1-0) ratios in low metallicity environments compared to those in normal (solar) metallicity environments. From these results, we have attempted to deduce the mass of H2 present in low metallicity environments, which may be substantially greater than that deduced from CO observations alone. The [CII] line is useful to probe the molecular content of low-metallicity dwarf galaxies, where the CO(1-0) line is not detected.

To understand the heating of the gas in such low metallicity environments, we have modeled the various dust components of several low-metallicity starbursting galaxies. Compared to Galactic cirrus, for example, these low-metallicity galaxies requires 2 orders of magnitude less PAHs to explain the observed dust spectra as well as a larger size range of small hot grains responsible for most of the MIR continua. This result is consistent with the destruction of PAHs in the harsh radiation fields of these objects.

Extragalactic chemistry of starbursts

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The HIFI instrument for FIRST will survey the molecular inventory of the ISM in nearby galaxies from the disks of starbursts systems to the toroids feeding or interacting with AGN engines. The chemical enrichment of molecular gas in the circumnuclear disks of starbursts, will be studied by the measurement of the FIR line spectrum with HIFI, for a significant sample of nearby spirals. Most importantly, the high spectral resolution of HIFI will allow to analyse the link between the chemical processing of gas and the onset of large-scale shocks related to the ubiquitous spiral/barred instabilities. With these aims, our group is conducting a interferometric survey of molecular gas in a selected sample of nuclear starbursts (including NGC253, M82, IC342, NGC3593, NGC891,...) and also, a parallel survey of AGN nuclei (including 15 spirals).
In this paper we present an extract of these surveys, including the first high-resolution SiO maps made in two external galaxies: NGC253 and M82. The nucleus of the nearby barred spirals NGC 253 and M82 have been observed simultaneously in the v=0, J=2-1 line of SiO and in the J=1-0 line of $H^{13}CO^+$ with the IRAM interferometer. Emission from SiO and $H^{13}CO^+$ is extended in the nucleus of NGC 253. The kinematics of the gaseous disk in NGC253, characterized by strong non-circular motions, is interpreted in terms of the resonant response of the gas to the barred potential. The link between chemical processing of gas and the onset of large-scale shocks is discussed, as well as possible follow-up studies by HIFI in this field by the observation of water lines, and high J rotation lines of CO, HCO^+ and CS.

Tracing the Molecular Gas in Star-forming Dwarf Galaxies: The Need for CII Observations

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CO emission proves to be an unreliable tracer for H_2, especially in the hostile environment of star-forming, low-metallicity dwarf galaxies. The X_{CO} conversion factor is far from being a (metallicity-scaled) constant for a galaxy but a truly local property and a sensitive diagnostic of the physical conditions of the studied regions. However, investigating X_{CO} in detail partly overcomes the feebleness of CO observations. We present results of an in-depth study of the molecular gas in the prototypical blue compact dwarf galaxy Haro 2. Virial mass estimates based on interferometric CO(1-0) & CO(2-1) data and radiative transfer analysis that includes the CO(3-2) and ^{13}CO lines, yield both low X_{CO} factors for (apparently undisturbed) molecular cloud complexes despite the low metallicity of Haro 2. This indicates that the shielding against CO photo-dissociation in low-mass galaxies is indeed not only correlated with metallicity but might more strongly depend on parameters like the structure of molecular cloud complexes. Such cloud characteristics may differ in dwarf galaxies. Preliminary results of our line ratio studies from mapping of the higher CO transitions in other dwarf galaxies (IC10, NGC 1569, NGC 5264, NGC 3077) also reveal very complex molecular phases - surprisingly in the more quiescent outer regions of some of these dwarfs. Obviously is our understanding of the distribution and energy balance of the dense ISM in low-mass galaxies very incomplete without the study of major coolants like CI and CII. While CI emission is directly associated with the CO emitting cloud cores, is CII more extended and probably better tracing the molecular complexes. The high spectral resolution of HIFI, the sensitivity and the small beam of FIRST at 158{SYMBOL 109 \f "Symbol"}m will allow detailed studies of the structure and energy balance of the ISM and its relation to star formation in a variety of dwarf galaxies beyond the local group. CII observations of dwarf galaxies will help to clarify the sometimes contradictory results on the state of the dense ISM in these extreme environments and provide valuable input for refined PDR models.

Session 11b

Water, ISM and Spectroscopy

Model predictions for H_2O emission/absorption in molecular clouds and circumstellar envelopes

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ISO/SWS observations of H_2O lines have provided valuable information about the water abundance in molecular shocks and envelopes sorrounding oxygen-rich evolved stars. Since H_2O is an important coolant in both type of sources, the physical conditions will be mostly determined by the excitation mechanism of this species. This will be the main subject of my contribution.

The excitation mechanism of H_2O levels depends on the excitation energy of the considered level, on the molecular hydrogen density, and on the radiation field, i.e., the dust emission. However, the relative importance of collisions and radiation in pumping of H_2O excited levels may strongly vary from source to source. On the other hand, it is now well stablished that the lowest-lying lines are observed in absorption toward some sources (i.e., SgrB2) and in emission toward others (i.e., OMC-1). Furthermore, in OMC-1 the far-infrared H_2O lines are in emission whilst lines with $\lambda < 60$ μm are in absorption (see the contribution by J. Cernicharo).

The problems outlined above will be discussed and related to future FIRST observations. Models for H_2O excitation will be presented and predictions for FIRST will be emphasized. The sensitivity and frequency resolution of FIRST will allow to determine much more precisely the physical and chemical conditions that can be derived from H_2O observations, and simultaneously to constrain much better our models of H_2O excitation.

Water line emission from the envelopes surrounding solar type protostars

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Water lines have been predicted to be the gas major coolants of the inner regions of the envelopes surrounding solar type protostars (Ceccarelli, Hollenbach & Tielens 1996; Doty & Neufeld 1997). Observations carried out with the Long Wavelength Spectrometer (LWS) on board the Infrared Space Observatory (ISO) satellite revealed strong water emission in several solar type protostars, confirming these early predictions (Ceccarelli et al. 1999). Indeed the analysis of the water lines from the solar type protostar IRAS16293-2422 allowed to reconstruct the physical structure of its envelope and to estimate the mass of the central forming star and its mass accretion rate (Ceccarelli et al. 2000). Yet, given the relatively low sensitivity, large spatial resolution and low spectral resolution, the ISO observations had some obvious limitations, which will be certainly surmounted by FIRST. With its higher sensitivity, spatial and spectral resolutions, FIRST will be able:

a) to increase the sample of solar type protostars where the study of water line emission is possible
b) to disentangle the water emission associated with the infalling gas against the emission due to shocked material of the outflowing gas
c) to resolve spectrally the line emission making possible kinematical studies: note that since high lying water lines originate in the innermost regions, where the infall velocity is the highest, they can be resolved by the HIFI spectrometer and used to probe the infall.

FIRST is the only instrument able to observe efficently and routinely water lines from solar type protostars in many years to come. In this contribution we will show how the water lines observable with FIRST can be used to derive some key parameters: e.g. the water abundance both in the outer cold regions of the envelopes and the hot core like regions where grain mantles evaporate; the mass of the central forming stars and their accretion rates. The knowledge of these parameters in a large statistical sample of solar type protostars is unvaluable to understand the process of the formation of these objects.

Large Atomic Oxygen Abundances observed toward Molecular Clouds

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Oxygen is the most abundant element after hydrogen and helium in the Universe. It is therefore of key importance to know in which form oxygen is found in the different phases of the Interstellar Medium. We performed ISO-LWS observations of the [OI] (63μm and 145μm) lines towards the molecular cloud L1689N (Caux et al. 1999) and the high mass star formation region W49N (Vastel et al. 2000). From the analysis of the [OI] lines using a LVG model, we derived the physical parameters of the regions (mean gas temperature and [OI] column density). Combining these observations with CO observations, we obtain [O]/[CO] ~ 50 towards L1689N and larger than 15 towards the molecular clouds on the line of sight of W49N.

In both observed regions, the derived [O]/[CO] ratio implies that up to 98% of gaseous oxygen is in atomic form in the gas phase. If we assume that all the gaseous carbon is locked into the CO (a reasonnable assomption), carbon has to be depleted by more than a factor of 6 with respect to the cosmic abundance.

No standard chemical models predicts such large [O]/[CO] ratios, neither the pseudo-time dependent nor in the steady state limits. Also, evidence is now mounting that CO depletion is a widespread characteristics of molecular clouds. Modeling efforts and new observations are clearly needed to make progress in this field. The 3 focal plane instruments of FIRST will allow to do that at high sensitivity and spectral resolution. FIRST will be the only instrument able to observe accurately the [OI] 145μm line which is of prime importance as the [OI] 63μm is generally optically thick. Indeed, the tremendeous improvement in the observation of these lines from the KAO to ISO showed the necessity of a space based instrument.

Observations of a nonstationary PDR

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We present imaging and spectroscopic observations of dust and gas emission from the western edge of the ρ Ophiuchi molecular cloud facing the B2 star HD 147889. This is a nearby PDR (PhotoDissociation-Region), $d = 135 \pm 15$ pc from the star parallax, with an edge-on geometry where the observations allow to spatially resolve the region of penetration of the external UV light and H_2 photo-dissociation. We have obtained a large body of observations on this PDR: ISOCAM images in the mid-IR emission, ISO-SWS pure rotational lines of H_2, image in the H_2 1-0 S(1) line and CSO observations of CI and CO lines. The H_2 rotational level populations provide a thermal probe which showing the presence of a gas with a temperature $T_{gas} \sim 300$ K. The ratio of ortho- to para-H_2 is $\sim$1 significantly smaller than the equilibrium ratio of 3 expected in gas at that temperature. Moreover, the comparison of the observed emission profiles with a stationary PDR model points at the importance of advection. In fact, PDRs with moderate-to-strong photon flux have a rapidly propagating dissociation front which affects stratified structure as well as the line emission profile of the gas.

FIRST will give a new perspective on the dynamic of this region. For example, HIFI and PACS will provide unique observations of the [C^+] 158μm line characterised by high spectral and spatial resolutions.

Using FRIST to probe the magnetic field with low-mass molecular ions.

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Abstract

Observations of the effects the magnetic field has on its environment are usually achieved using techniques which rely on its interaction with the spin of the particles under study. Because of the relative weakness of this effect, extraction of the field characteristics proves to be a most challenging task. We have recently presented a totally different approach to the problem and showed how and why a manifestation of the presence of the magnetic field can be directly detected in the spectra of ionic molecular lines. Our model makes predictions concerning the expected differences between the line profiles of coexistent ion and neutral molecular species and between ions of different mass. We have already published observational evidence in support of these predictions with spectra of neutral (HCN, $H^{13}CN$) and ion (HCO^+, N_2H^+, $H^{13}CO^+$, HCS^+) species of relatively high mass obtained in a sizable sample of molecular clouds. Because of its frequency range, FIRST would allow us to study low-mass molecular species (CH^+, H_3O^+, ...) that are otherwise difficult or even impossible to observe with ground-based telescopes. We could then verify the applicability of our model to such molecular species and test the mass dependency that it predicts.

Session 13

Circumstellar & Interstellar Matter

Evolved stars, Post-AGB Objects and Planetary Nebulae: Dust properties and energy distributions

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This review will address the potential of FIRST for advancing our understanding of the late stages of stellar evolution represented by AGB stars, post-AGB objects and planetary nebulae, whose copious mass loss leads to the enrichment of galaxies in dust and heavy elements. The advances made by ISO will be reviewed, including the discovery of the widespread presence of emission features due to crystalline silicates and water-ice at far-infrared wavelengths. Our current understanding of the relevant properties of the dust in these objects will be summarised, and the potential applications of the spectroscopic and mapping capabilities of FIRST to the study of these sources will be discussed.

The diffuse interstellar medium

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The diffuse interstellar medium, with its ionized, atomic and molecular components, contributes a major fraction of the far infrared and submillimeter line and continuum emission of the Milky Way and external galaxies. FIRST will give access to the main cooling lines of the diffuse interstellar medium, and to the diffuse continuum emission, with an unprecedented sensivity and spectral resolution. Many issues such as the properties and spatial distribution of the interstellar medium phases will benefit from FIRST data. These issues are connected to crucial questions for extragalactic astronomy, for example the propagation of UV photons through the disks of spiral galaxies and the down conversion of UV photons to the far infrared and submillimeter. In addition, new perspectives on the chemical composition of the diffuse interstellar medium are expected, from full the opening of the submillimeter spectral window.

From ISM to protoplanetary dust

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Session 14a

Instruments

Implications of the Pronaos observations for large scale surveys with FIRST

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We will present recent sub-millimeter (200-600 μm) observations obtained with the balloon-borne experiment Pronaos. These have lead to exciting and sometimes unexpected new results regarding the nature, the composition and chemistry of dust grains in the ISM. In particular, they reveal dust significantly colder than expected (T=12 K) in translucent and optically thin dust clouds at high galactic latitude, which can be interpreted as evidence for the existence of fractal dust aggregates in diffuse clouds. The Pronaos observations also show a significant anti-correlation between dust equilibrium temperature and the spectral index of its emissivity law in the sub-millimeter. This may reflect quantum processes within the grains that appear only at low temperature and thus brings new insight on the nature of large dust grains in the ISM. Owing to the wavelength range covered and the high sensitivity achieved, the Pronaos observations prefigure what will be possible on large scale and higher angular resolution with FIRST. These results strongly argue in favor of a large survey of the diffuse ISM with FIRST and have direct implications about how to conduct such a survey.

ELISA: A small balloon-borne experiment to guide future observations with FIRST

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ELISA (Experiment for Large Infrared Survey Astronomy) is a project for a small balloon-borne experiment operating, in the sub-millimeter from 100 to 600 μm, at stratospheric altitude. We will describe the experiment and its scientific objectives. A major goal of the ELISA project is to provide a complete census of dust emission in this wavelength range, at an angular resolution similar to the IRAS all-sky survey (typically 3.5'). Current plans envision 3 flights (including one in the southern hemisphere) before 2007, leading to a large survey along the Galactic plane (typically 5000 square degrees) as well as deeper observations toward high latitude cirrus clouds. The ELISA survey will therefore be available and well suited as a guide to plan FIRST observations, similar to the role of IRAS for ISO. In addition, by filling the angular resolution gap between the COBE and FIRST data-sets, the ELISA survey could enable routine cross calibration between the COBE and FIRST observations.

Strategies for HIFI line surveys

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One of the activities of the HIFI instrument will consist in performing unbiased or partial line surveys of astrophysically interesting regions. In this contribution, recent results from ground based instruments are discussed, and strategies to obtain the maximum scientific output with HIFI are developed. The discussion addresses source selection criteria, selection of bands for partial line surveys and survey modes - e.g. deep vs. shallow surveys. Important aspects for planning the observations are also simulations of the expected spectra, tools for extracting the relevant information out of the data, and ground based observations to be performed to serve as a basis for these simulations. The existing data base is reviewed, and suggestions for preparatory and supporting observations with existing instruments are made.

Absorption Measurements of Cold Halo Gas: FIRST's Sensitivity

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Given the sensitivities presently estimated for the FIRST instruments, in particular the high resolution spectrometer HIFI, I will discuss FIRST's ability to detect cold halo gas by absorption against extragalactic background sources in the important fine structure lines of abundant species accessible to FIRST. I compare this to the limits reachable by observations with other instruments and in other wavelength bands.

The submillimetre satellite ODIN

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ODIN is a Swedish-international satellite for astronomy and aeronomy, with foreign partners being from Canada, Finland and France. ODIN will be launched in early 2001. To achieve its twofold objectives, ODIN will use its tunable heterodyne receivers to collect spectroscopic data in primarily the submm spectral domain of both astronomical objects and the atmosphere of the Earth.

ODIN's astronomical science focuses naturally on similar areas as FIRST's, with a strong weight on the physics and chemistry of the star forming interstellar medium in our own and in other galaxies. First ranked observations will specifically address the key molecules H_2O and O_2. To achieve optimum sensitivity for the detection of molecular oxygen, a 119 GHz receiver will be flown on ODIN. For water, the 557 GHz ground state line will be observed as well as the $H_2^{18}O$ isotopomer. In addition, transitions from other species (C, CO, CS, NH_3 etc.) are also admitted by the receiver bands.

The expected scientific capabilities of ODIN, resulting from the wide frequency coverage and the comparatively small beam size (2 arcmin at submm wavelengths) will be discussed with respect to the achievements of SWAS and also be put into perspective to those foreseen for FIRST. At this stage of FIRST planning and programmatic discussions, the adopted philosophy regarding the implementation of the ODIN programme may also be of interest.

The Large Millimeter Telescope (LMT/GTM) in relation to FIRST

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I will review the current status of the 50 m main reflector telescope construction at 4600 m (La Negra, Puebla, Mexico). This is the largest purely scientific project ever undertaken by Mexico. Construction is expected to be finished in 2003. The LMT is a joint INAOE (Puebla, Mexico) and Umass (Amherst, USA) project) that will operate at 0.85-3.4 mm. When fully operative the 126 panels on the active mirror are expected to provide an overall surface accuracy of 75 microns and it will be able to map 1800 arcmin/hr/mJy. (For more details see: www.lmt.gmt.org). I will briefly review the potential of the LMT/GTM to explore the high-z universe (cold and hot) in the context of the FIRST mission. The LMT/GTM complements FIRST and ALMA in many aspects, specially regarding photometric surveys (e.g. intermediate resolution, mapping speed, wavelength). To maximize the scientific return of these projects it is important to explore the possibility of overlapping key programmes.

First Results with CHAMP, the Carbon Heterodyne Array of the MPIfR

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A 16-element SIS heterodyne array for operation in the 625 μm atmospheric window has been developed at the MPIfR. The array consists of 2×8 elements with $\sqrt{2} \cdot \theta_{mb}$ pixel spacing on the sky. The L.O. tuning range covers the astrophysically important fine-structure transition of neutral atomic carbon [CI] and the J=4-3 rotational transition of excited carbon monoxide. An IF bandwidth of 2 GHz (1200 kms^{-1}) permits mapping of broad-line extragalactic systems. For best system sensitivity the design allows for cold optics (@ 15K) and single-sideband operation. The frontend is linked to a flexible autocorrelator, with a maximum bandwidth of 2 GHz (2048 channels) for each of the 16 elements. In the high-resolution mode, 500 MHz of bandwidth can be operated with 8192 channels of 61 kHz spectral resolution.
The array was successfully commissioned at the CSO 10.4m Leighton telescope on Mauna Kea (Hawaii) in February 1999. However, due to unsuitable post-*El Nino* weather patterns during several observing sessions, only this September astronomically useful data could be gathered. We will present some of the astronomical highlights.
Taking advantage of the high mapping speed and image quality of this first submm focal-plane array, CHAMP will serve as pathfinder for many projects in the pre-FIRST days. We will discuss the capabilities and limitations of the system, potential near-term upgrades, and its availability to the interested community.

Session 14b

Galactic Surveys

&

Evolved Stars and Dust, Part 2

JCMT SCUBA-Diving in Nearby Molecular Clouds: The Case for Large Systematic Surveys with FIRST.

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I will present results from two sub-millimetre surveys of nearby molecular clouds: ρ Oph, Taurus, Orion A and Orion B. Combining large area (100's of square arcminute) JCMT continuum emission images at 450μm (8") and 850μm (14"), sensitive to $\sim 0.01\,M_\odot$ condensations, with molecular line data (CO isotopes, CS, formaldehyde, etc.) allows for a glimpse into the physical properties of molecular clouds on small scales. Both barely resolved condensations and large scale features are visible in the maps, revealing the variety of dynamical events which operate in star forming regions. I will discuss the important physics associated with these regions, as evidenced by the survey results: the formation of filamentary structures with threaded magnetic fields, sculpting of the medium by outflows, shocks in jets, and the temperature and dust emission properties of both large scale and compact structures. I will also present a model of the many compact clumps found in the dust continuum images in order to derive their physical properties - mass, temperature, and bounding pressure. The cumulative mass function for the clumps in both Orion and ρ Oph is remarkably similar to the stellar IMF. These results will be used to argue for a strong multi-wavelength and multi-instrument survey component to the FIRST mission in order to best unlock the secrets of star formation in molecular clouds.

Young stellar clusters: from ISO to FIRST

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Young stellar clusters can be studied statistically to address various fundamental questions of astrophysics: initial mass function (IMF), star forming history and early stellar evolution. Significant amount of ISO time was dedicated for these purposes to map close by star forming regions: Chamaeleon I, rho Oph cluster, Serpens, R CrA cluster, LDN 1641, NGC 1333, parts of the Taurus clouds etc. The results are consistent with a scenario where the high activity of star formation is only of short duration. The IMF if consistent with that of field stars with an extension toward brown dwarfs mass domain with the same power law as for very low mass stars.

One of the interesting results of the ISO studies of young clusters is the clear separation of stars with and without infrared excess when observed at 6.7 and 14.3 micron. The importance of this result is due to the fact that it is very difficult to disentangle infrared excess from extinction if only ground-based near-infrared JHK data is available. The reason for superiority of ISO data in this respect is due to the low and very similar extinction at 6.7 and 14.3 micron. Therefore the observed ISO colour is very close to the intrinsic colour. The gap in the ISO [6.7]-[14.3] colour separates clearly stars with and without infrared excess. Furthermore, the lack of intermediate cases suggests that the disk dispersal, when started, is a very rapid process.

The disk dispersal time is going to be one of the key issues to be addressed by FIRST. Young stellar clusters provide an excellent target to probe this process. Ground-based and ISO results indicate that circumstellar disks disappear before stars reach an age of a few times 10^7 years. However, this is true only for the inner parts of the disk. The dispersal of the cooler parts can only be addressed at wavelengths longward of 60 micron, but at these wavelengths IRAS, ISO and SIRTF all hit the problem of confusion. It is the resolving power of FIRST which will be crucial in addressing the dispersal time scale of the cooler parts of the circumstellar disk. This information is needed to see if the inner disk dispersal seen in young clusters have any relation to the debris disks in field stars which have dispersal time scale of the order of 400 million yers.

This presentation will review the ISO results of star formation history and IMF in young clusters and show the expected contribution of FIRST in this science area. The current understanding of disk dispersal will be reviewed and the need for FIRST will be discussed to show the potential in clarifying the issue of dispersal of the cooler parts of the circumstellar disks.

The physics of cold matter far from UV sources

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We will present two observational results opening two new perspectives on the Galactic ISM. (1) A recent analysis of the origin of the sub-millimetre Galactic dust emission measured by FIRAS points at a very cold (T = 5 - 7 K) emission component in the Galactic disk with an intensity independent of the longitude, (2) The detection of H_2 pure rotational lines up to S(3) with ISO-SWS in a galactic line of sight avoiding star forming regions reveal traces of warm gas (about 1%) within the cold ISM.

Both results apply to matter far from UV sources. The former implies large amounts of cold dust, and therefore cold gas, in the outer galaxy. The latter implies H_2 excitation processes different from fluorescence such as collisional excitation in regions of enhanced dissipation of turbulence. Their link is the following: the cold gas in the outer Galaxy is likely to be molecular and too cold to be seen in emission except in the very localised regions where dissipation of turbulence is large enough to heat the gas up.

We will propose dust and gas observations which will determine the amount of matter traced by the very cold dust emission and which, with the help of modelling of turbulence dissipation, will further characterise the non-stellar energy sources of the warm gas emission.

Mapping the evolution of dust particles in the Cold ISM

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The evolution of dust particles in the Cold ISM (CISM), from diffuse interstellar clouds ($A_v<0.1$) to dense molecular cores ($A_v>3$) is thought to result from accretion, coagulation and shattering processes. We will review current observations allowing the characterization of these evolutionary processes, essentially from IRAS, COBE, ISO and SPM-PRONAOS data. We will show that, because of the lack of spectral coverage combined with spatial resolution, these observations only give a fragmented description of the major physical processes.

We will discuss the unprecedented mapping capabilities of the two instruments PACS and SPIRE which will offer an unique opportunity to study the evolution of the dust particles in the CISM. Moreover the combination with SIRTF data (more than 50 square degrees will be mapped in the CISM, from 3.6 to 160 microns) will constitute an unique database in terms of the number of resolution elements and wavelength coverage. For the first time, the Spectral Energy Distribution from 3.6 to 600 microns will be measured in individual structures of the CISM. It will give strong constrains on the size distribution of small dust particles and the emission properties of the large grains in thermal equilibrium with the radiation field.

Search for PAH-like species with HIFI

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Thanks to the great data recently obtained by the Infrared Space Observatory, progress has been made on the characterization of the carriers of the "Unidentified" IR bands. Polycyclic aromatic hydrocarbons or closely related species seem to be the best candidates to account for these bands. Although no individual species could be identified, limits can now be put on their size distribution, in particular on the minimum size, which is an important tracer of the formation and of the processing of these species in the interstellar medium.

In this paper, we show how the HIFI instrument on board of FIRST can contribute significantly to this subject. PAHs are expected to emit in their low-frequency vibrational modes in the submillimeter range. Thanks to its very high resolution, HIFI has the unique capability to detect the rotational structure of these floppy modes, giving fundamental information on the size and shape of the emitters. Observations can be planned in regions submitted to UV photons where the UIR bands are well observed but also in more embedded objects. Besides the characterization of the emitting species and ultimately their identification, this work could have implications on the understanding of the physics and chemistry of the interstellar medium.

Evolution of the dust properties in a translucent cloud.

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The balloon borne experiment SPM-PRONAOS has measured the submillimeter emission from 200 to 600 µm with an angular resolution of 2-3.5' of a quiescent translucent filament (A_V~4) in the Taurus molecular complex. We show, from the combination of these new data with IRAS data, that (1) transiently heated small particles are not present inside the filament, and (2) the temperature of large grain in thermal equilibrium with the radiation field significantly decrease from the outer to the inner parts of the filament.

We have developed a model for the emission of the filament using an independent tracer of the total column density (from the 2MASS star catalog, Cambresy et al.1999) and the radiative transfer code developed by Le Peintre et al.~(2000). We first use the optical properties of the dust from the standard model of Désert et al.~(1990). The computed brightness profile fails to reproduce the data inside the filament. The agreement between data and model can only be found by removing all particles not in thermal equilibrium from the densest part of the filament (typically $n=\sim10^4\sim cm^{-3}$), and multiplying the submillimeter emissivity by a significant factor. This suggests that grain-grain coagulation into fluffy aggregates has occured.

These results highlight the promising impacts of PACS and SPIRE on the understanding of the evolution of interstellar dust particles in the diffuse parts of our galaxy.

Active dust formation by Population I Wolf-Rayet WC stars

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ABSTRACT.

We review studies of heated dust formation around Wolf-Rayet stars, observed in the infrared with groundbased *JHKLMN* photometry, Keck-2 IR image masking interferometry, and *HST*-NICMOS IR imaging. Periodic fresh dust formation with periods of the order of ten 10 years has been discovered for three WC+O binaries, episodic dust formation has been found for another four WC+O stars, while persistent dust formation is known for 18 WC8-9 stars. Of the last category two stars have been imaged by Keck-2, showing rotating pinwheels in the sky with periods of the order of one year.

Ramifications of the existence of heated amorphous carbon dust formation in the hot ionized stellar winds of WR stars will be discussed. Dust formation is the least understood of all phenomena associated with colliding stellar winds in WR+OB binaries, including also non-thermal radio emission and variable X-ray and $\gamma-$ray emission. While those phenomena are associated with the top of the wind-wind collision cones, dust formation is happening in the wake of the collision cones, at distances of a few hundred stellar radii, and thus is associated with the circumstellar and interstellar matter around these hot evolved massive stars. After formation, the dust is being carried away by the WC stellar winds and cools gradually to interstellar temperatures. The cooling dust very likely effects also the wavelength regions where *FIRST* operates.

Poster Papers

The origin of the bipolarity in the post-AGB evolution: the case of OH 231.8+4.2

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One of the most debated issues on the post-AGB evolution of mid-mass sources is the question of the origin of the bipolarity often observed in PNe and PPNe. Today, it is firmly established that PNe are the result of the post-AGB evolution of the CEs around AGB sources. However CEs in the AGB are spherically symmetric, as the result of an isotropic mass loss due to photon pressure of the dust grains. Is though that the origin of this symmetry breakup at the end of the AGB, is due to the interaction a fast and highly collimated post-AGB wind of the old spherical CE.

To study the details of this interaction, and the nature and origin of the post-AGB ejections, we have undertaken a series of multi-wavelength imaging of selected post-AGB sources. Here we present the results of our studies on OH 231.8+4.2, a beautiful bipolar nebula surrounding a late AGB star. We have carried out high resolution observations of the molecular component (interferometric maps of CO and some tracers of shock chemistry), the circumstellar dust (broad band NIR imaging), and of the shocked excited hot phase (atomic line long-slit and imaging). These works have been very revealing but we still lack of information on the mid-excitation gas in this source (OH 231.8+4.2 could not be observed with ISO). The study of this component is of fundamental importance for better understanding how the shocks responsible for the nebular bipolarity operated, and what is their energy source. The observations of sub-mm molecular lines are crucial in this respect. On the other hand, due to its large extent, kinematics and molecular richness, this extremely interesting PPNe constitutes an ideal target for the HIFI instrument on-board the FIRST satellite.

The circumstellar environment of MWC297: ISO results and FIRST expectations.

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The ISO SWS and LWS full grating spectra of the Herbig Ae/Be star MWC297 are presented. The spectra are dominated by a strong continuum; in addition in the SWS range (2.3-45μm) emission lines from the HI recombination series, PAH emissions and absorptions by solid CO_2, H_2O, and silicates have been observed while in the LWS spectrum (45-200μm) [OI] and [CII] fine structure lines have been detected.

The NIR-FIR data have been combined with ground based photometry to derive the spectral energy distribution (SED) from optical to radio wavelengths. The observed SED has been compared with the SED's computed with a spherical dusty envelope model parametrized by a density and temperature law in order to derive the spectral type, the A_V and the distance. Consistent determination of the extinction plus estimations of the source mass loss rate and the dimension of the emitting ionized region have been derived by the analisys of the HI recombination lines of the Brackett, Pufnd and Humphreys series observed by ISO together with Paschen, Brackett lines observed from ground.

The results are somewhat hampered by the (partly for SWS) large beam size of the ISO instruments. We then will show how the large spatial resolution of PACS can be used to improve our understanding of the physical conditions in the close neihgborough of MWC 297 and, more general, to shed light on the unsolved problems regarding the circumstellar environment around the Herbig Ae/Be stars.

The ^{12}CO(1-0) to H_2 conversion factor in normal late-type galaxies:the contribution of FIRST

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The molecular gas mass in nearby galaxies is generally estimated using ^{12}CO(1-0) line intensities assuming the X conversion factor between I(CO) and N(H_2) measured in the solar neighborhood. It is however known that this X conversion factor is not universal since it changes with metallicity, cosmic ray density and UV radiation field. Far-IR data in the spectral range 100-1000 μm can be used to estimate the molecular gas content of late-type galaxies in an independent way of CO line measurements once a constant dust to gas ratio is assumed, allowing a direct estimate of X. This exercise is here presented for a large sample of galaxies with available multifrequency data using ISOPHOT and IRAS far-IR data. This analysis, which is extremely useful to study the properties of the ISM of galaxies spanning a large range in luminosity and morphological type, is however limited by the lack of photometric data in the range 100 μm $\leq \lambda \leq$ 1000 μm, the spectral demain observed by FIRST.

The FIR/submm end far-ultraviolet emissions of galaxies: The FIRST and GALEX surveys

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The comparison of the far infrared and far ultraviolet emissions of galaxies in the local universe has demonstrated that

- these two emissions are very complementary star formation tracers
- the ratio of the FIR to FUV emission is a very powerful and robust tracer of the dust extinction within star forming galaxies.

GALEX is a UV satellite which will observe in the far-uv and near-uv both in imagery and spectroscopy. Its launch is scheduled in 2002. The cross-correlation between the PACS and SPIRE surveys and the GALEX survey will extend the very preliminary work already made with IRAS and FOCA (balloon borne UV experiment) data.

In this poster we will discuss the characteristics of the cross-correlated samples given the limiting magnitudes expected with GALEX and FIRST such as selection biases, number of objects, redshift distribution...

We will also present the scientific topics which can be addressed with such data

ISO Far-Infrared Spectroscopic Observations of Jupiter

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We present the far-infrared spectrum of Jupiter that was measured with the Short and Long Wavelength Spectrometers (SWS and LWS) aboard the Infrared Space Observatory (ISO). The region between 30 and 45 μm was observed in grating mode, where the SWS provides a spectral resolution of 1000 - 1600, depending on wavelength. For longer waves up to 197 μm the LWS-FP (Fabry-Perot) was used to achieve a resolution of several thousand. The observations were made between 23 and 26 May 1997 during ISO's revolutions 554, 556 and 557.
The Jovian spectrum in the far-infrared is compared to an atmospheric radiative transfer model using expected values for the constituent vertical concentration profiles. Rotational transitions of ammonia and phosphine are responsible for the absorption features observed: Strong ammonia absorption manifolds are obvious against the background continuum slope, appearing at 39, 42, 46, 51, 56, 63, 72, 84, 100, 125 and 168 μm in both the data and the model. Also PH_3 absorption features are clearly present; we found them at the expected wavelengths of 113, 141, 161 and, somewhat spurious, 188 μm. This is the first time that most of these far-infrared features have been detected. The ISO observations are therefore of great value for the preparation of the planned submillimeter studies of the atmospheres of the Jovian planets with FIRST.

Spectroscopic properties of new IR galaxies detected in the European Large Area ISO Survey

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We present the spectroscopic properties of a sample of galaxies detected in the mid and far-IR in the European Large Area ISO Survey. The sample includes several types of objects in a wide range of redshifts, (starburst, type 1 and 2 AGNs, high z quasars and also galaxies without emission lines). The spectroscopic data have been obtained in the follow-up of the ELAIS survey, using several telescopes and instruments: fibre spectroscopy with WYFFOS on the WHT at the Observatorio del Roque de los Muchachos (ORM), HYDRA at WIYN observatory, long-slit spectroscopy at the WHT, NOT at ORM and 2.2m telescope at Calar Alto. We present a preliminary classification of the objects, the distribution of the different types with redshift and other properties as line ratios of important emission lines, equivalent widths, continuum features, etc.

OSIRIS-FIRST Scientific Program

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OSIRIS (**O**ptical **S**ystem for **I**maging and low/intermediate-**R**esolution **I**ntegrated **S**pectroscopy) will be one of the Day One instruments for the Spanish 10.4m telescope GTC at La Palma. One of the scientific projects to be addressed with OSIRIS is the study of the galaxy population in clusters of galaxies at high redshift. Part of the cluster sample could be selected by means of the Sunyaev-Zel'dovich effect as provided by the Gran Telescopio Mexicano (GTM). The optical survey will be complemented using other future facilities in the NIR such as the Espectrógrafo Multiobjeto InfraRojo (EMIR), also in the GTC. The interaction with FIR (FIRST) and mm/submm (GTM, ALMA) instruments will complement the view. The spectroscopic and photometric capabilities of PACS and SPIRE covering the spectral range 60 - 670 μm, will be both feed with this survey and will allow us to extend it. The combination of the OSIRIS and FIRST capabilities will provide a deep insight into the evolution of cluster galaxies. We present the OSIRIS Scientific Program, their goals and future follow-up and extension using FIRST.

On the nature of carbon stars

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This paper is concerned with the nature of carbon stars. Data from the IRAS survey have shown that carbon stars which were identified from optical surveys and those identified from the SiC dust features in their IRAS-LRS spectra have different IRAS colours. The former (which be referred to as visual carbon stars) are visually bright and have large excesses at 60 μm, while the later group (which will be referred to as infrared carbon stars) have blackbody energy distributions. Model calculations are presented on the evolution from the visual carbon stars to infrared carbon stars, and on the evolution of infrared carbon stars. A two-shell model (the interrupted mass-loss model) has been developed with an oxygen-rich detached shell and a newly forming SiC dust shell. The model tracks successfully explain a "C"-shaped distribution of carbon stars in the colour-colour diagram. The existence of these transition objects with infrared properties intermediate between visual and infrared carbon stars, lends further support to the idea of an evolutionary link between visual and infrared carbon stars. For some objects in the working sample observational data (such as ISO, IRAS and optical near-infrared photometry) are available. The energy distributions generated by the model are compared with the available data of these objects. This comparison will be presented and discussed. The data from FIRST will be very useful for further investigating this idea in details.

WAITING FOR FIRST: THE EVOLUTION OF MOLECULAR OUTFLOWS

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We review some aspects of our research activity, based on ground-based mm-wave and ISO observations, which have been addressed in the effort to investigate the evolution of the molecular outflows associated with star forming regions. The approach given by the study of the shock chemistry has been used, observing emission due to molecular species as e.g. SiO, H_2O, H_2S, SO, SO_2. The results suggest criteria based on line profiles and abundance ratios which allow to get the evolutionary stage of the young stellar objects driving the mass loss process, and call for the study of emission due to high excitation transitions of Si-, O- and S-bearing molecules which occurs at the FIRST frequencies. The high spectral resolution given by HIFI as well as the PACS and SPIRE capability to obtain imaging spectroscopy of quite extended star forming regions represent an unique opportunity to investigate the high temperature chemistry, tracing the high excitation conditions associated with the region closely linked with the shock front.

STAR FORMATION IN THE BRIGHT RIMMED GLOBULE IC1396N

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The bright rimmed globule IC1396N has been investigated through a multiline survey at mm-wavelengths. In order to probe a wide range of physical conditions, emission due to CO, CS, DCO^+ and SiO has been observed. The present results, combined with previous ISO observations, allow to study how the presence of massive stars can affect the structure of the dense molecular clouds in the surroundings triggering the process of star formation. The occurrence of several bipolar molecular outflows and dense cores shows a quite complex scenario indicating that IC1396N hosts different regions where the star forming process is running. The results call for high angular and spectral resolution observations at submillimetre and infrared wavelengths tracing high excitation conditions throughout the globule making IC1396N an ideal target for the future FIRST mission.

Simulating a FIRST sight: spectral line surveys at THz frequencies

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The Far InfraRed and Submillimeter Telescope will soon start producing copious amounts of data. By that time, we will have to be prepared to handle and analyse them properly. With this in mind, we are currently producing synthetic spectra of high-frequency molecular line emission towards star forming regions in order to simulate observations with the FIRST HIFI instruments, and implement a proper data reduction software. As, at THz frequencies, galactic sources are often spatially resolved, and small pointing offsets can produce important variations in the spectral features, the spatial distribution of the different chemical species is also taken into account. In this poster we will focus on the well-known Orion-KL region. These simulations make use of the JPL catalog data, as well as of the molecular abundances deduced for this source through unbiased line surveys at submm wavelengths (Schilke et al. 1997 and 2000). The introduction of the chemical differentiation in a simulation program will be a step towards a much more ambitious project, that of fitting whole spatially resolved line surveys.

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Titan observations with ISO

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Preceding FIRST, the ISO satellite offered great possibilities for observing, among other, solar system objects. In the case of Titan, Saturn's largest satellite, ISO set a milestone in our understanding of the physical processes acting in its atmosphere, but also gave us some insights on its surface.
In the spectroscopic mode, Titan was observed by ISO in 1997 by SWS, PHT-S and CAM/CVF. The combination of this data provides Titan's spectrum from 2.5 to 17 micron with resolving powers of 3000 at the most. The analysis of the spectra has provided information on Titan's atmospheric structure (temperature and composition, [1,2]) and on its surface (through the emission observed in the 2.9-micron window). In particular, ISO/SWS observations allowed us to detect for the first time the spectral signatures of water vapor near 40 micron [1]. Also, the 2.9 methane window was observed in its full shape for the first time [3].
All of this information is a valuable supplement to the optimization of the Cassini/Huygens mission, to reach Saturn's system in 2004. FIRST may well bring the required follow-up to the mission return, after 2007, with an extension of the ISO spectral region and higher capabilities.

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Observations of Mars at Infrared and Microwave Wavelengths: Perspectives For First

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Observations of Mars have been obtained in July 1997 by the two spectrometers of the Infrared Space Observatory, in the range 2.3-180 microns. By comparing these data to radiative transfer models, the water vapor column density and the saturation altitude have been inferred (Burgdorf et al., 2000, Icarus 145, 79).Using this information, the far-infrared part of the Mars spectrum was modelled in order to retrieve information on the emissivity of the Martian surface. Signatures of carbonates might be present between 30 and 40 microns, as well as in the 7-13 micron range (Lellouch et al., 2000, Plan. Space Sci., in press). Spectral signatures, possibly due to silicates, seem to be also present at wavelengths longer than 50 microns (Burgdorf et al., 2001, ESA SP-456, in press). Observations of Mars with FIRST, using the PACS and SPIRE instruments, are expected to provide new information on the emissivity of the Martian surface at far-infrared and submillimeter wavelengths.

Molecular lines formed in the Martian atmosphere are very narrow, due to the combination of the small pressure broadening (surface pressure is only 7 mbars) and a minimal thermal broadening. Heterodyne spectroscopy provides the capability of measuring individual line shapes and is thus especially suited for the study of these spectral lines. Ground-based observations of HDO and H_2^18O have been obtained with the IRAM-30m antenna in April 1997 (Encrenaz et al., 2001, Plan. Space Sci., in press). The quality of our data, however, was not sufficient for improving the determination of D/H on Mars (currently 6 +/- 3 times the terrestrial value; Owen et al., 1988, Science 240, 1767). Observations of H2O and its isotopes with FIRST-HIFI will allow a new determination of this important parameter with a much better accuracy. In addition, FIRST-HIFI will be well adapted to the search for minor species (such as H2O2, O2, O3 or HCl) at submillimeter wavelengths (Encrenaz et al., 1995).

Water in Star Forming Regions

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High spectral resolution observations of multiple transitions of water from disks around protostellar disks should provide a significant breakthrough in our understanding of this phase of the star formation process. Some preliminary results from a numerical model treating the radiative transfer of water in some simple disk models will be presented and implications for the FIRST mission will be discussed.

Far Infrared line cooling in Class 0 objects

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We have conducted with ISO-LWS a study of the far infrared line emission of a sample of 17 Class 0 objects and their associated outflows. At variance with more evolved young stars, such as Class I and pre-main sequence stars, the investigated spectra show a copious molecular emission in the form of CO, H_2O and, to a minor extent, OH transitions. Our analysis demonstrates that the bulk of the emission arises from very small, dense and warm regions, where the ambient gas is heated by non-dissociative shocks, associated with the high energetic outflows characterizing this early phase of star formation. However, several questions remain still unanswered. Given the poor spatial and spectral resolution of ISO, emission coming from multiple regions or excited by different mechanisms has remained unresolved; the role of water, predicted to be a dominant ingredient by shock models, is still not conclusive due to the large uncertainty affecting the abundance determinations; the contribution to the overall gas cooling due to important molecular lines emitted in the sub-mm range is remained unknown. The spectral and spatial resolution of the instrumentation aboard FIRST are well suited to investigate these questions and definitively define the energetic in the outflows from these very young protostars.

Spectroscopy of Key molecular species in the Far–Infrared

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Instruments on-board FIRST will provide high spectral resolution observations of the Far–Infrared and Submillimeter spectrum of dense molecular clouds. Not only physical, chemical and kinematic environments will be scrutinized. Detection of new polyatomic molecules and the use of known molecules in a broader range of transitions (some of them never observed before!) will offer unique tools for the understanding of dense star forming regions such as Sagittarius B2 molecular cloud. However, determination of the dominant carriers of emission/absorption features in new spectral bands requires an exhaustive knowledge of molecular spectroscopy and some experience with 'old' instruments and close wavelengths.

In this poster we analyze the type of molecular transitions and the contribution of polyatomic molecules to the Far–Infrared spectrum of interstellar and circumstellar clouds. For that aim, we present our recent work on **molecular first Far–IR detections**. All the results presented here were taken in the direction of Sgr B2. Our study is based on Fabry-Perot observations carried out with the Infrared Space Observatory (ISO) Long-Wavelength Spectrometer (LWS).

These first Far–IR identifications include: rotational transitions of light molecules with significant electric dipole (NH and NH_2), vibrational bending modes of very low-energy (C_3), b-type transitions of slightly asymmetrical molecules ($HOCO^+$) and inversion transitions of molecules having a small barrier in a double minimun vibrational potential (H_3O^+).

The Millimeter and Submillimeter Spectrum of CRL 618

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HIFI, the very high resolution heterodyne spectrometer will be able to carry out full spectral line surveys in the submillimeter domain (from $\simeq$0.6 to $\simeq$0.2 mm). Thus, many molecular, atomic and ionic lines will be observed in a fast way with high resolving powers.
In this poster we present for the first time a complete spectral survey of CRL 618 at λ= 3, 2 and 1 mm. Data were taken using the 30 m IRAM telescope between 1999 and 2000 and complemented with Caltech Submillimiter Observatory (CSO) observations. CRL 618 is one of the few clear examples of a C–rich proto-planetary nebula. Extreme physical conditions due to strong UV radiation field and large shocks associated with high velocity winds clearly modify the chemical compositon of its circumstellar envelope. CRL 618 spectrum is characterized by a forest of molecular and recombination lines. Mainly, pure rotational lines from ground and highly vibrationally excited states of HC_3N, HC_5N, HC_7N and its ^{13}C subtituted species contribute to the detected features. Lines show P–Cygni profiles at 3 and 2 mm and emission profiles at 1 mm and shorter wavelengths. This kind of surveys, in addition to being an excellent overview of the molecular content of this circumstellar envelope represents a preparatory study of the programs that could be carried out with FIRST/HIFI and also with PACS and SPIRE.

Deep Optical and Near-IR imaging in the ELAIS areas

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ELAIS (European Large Area ISO Survey; Oliver et al, 2000) is a project that has surveyed about 13 square degrees of high latitude sky in the north and south hemispheres using the ISOCAM and ISOPHOT cameras on board of the ISO satellite. Observations at 6.7, 15, 90 and 175 μm have been obtained. These observations together with the extensive followup programs carried out in these regions have made the ELAIS fields excellent areas for multiwavelength observations. These include radio observations using VLA, optical and near-IR, sub-mm and X-rays using Chandra and XMM. We report here the results of our deep optical and near-IR observations on the centers of the northern areas N1 and N2, regions that will be covered also by deep Chandra and XMM observations. We have obtained g', r', i' and H deep images with limiting magnitudes of g'=3D26.7, r'=3D26.2, i'=3D25.0 and H=3D20.2 (3σ detection limit) covering two areas of 30'$\times$30' arcmin using the Wide Field Camera (WFC) and the Cambridge Infrared Survey Instrument (CIRSI) both on the Isaac Newton Telescope (INT) in the Observatorio del Roque de los Muchachos, Canary Islands. These data are extremely useful to identify the faint optical counterparts of the ISO, radio and X-ray sources.

Infall in starless cores

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Star formation is a highly inefficient process. Some patches of a GMC form stars; most do not. Is there a necessary condition for star formation a core must fulfill? Large area molecular line surveys indicate that starless cores all have column densities less than 8×10^{21} cm^{-2}. A preliminary HCO^+ J=3-2 survey of starless cores, objects of great interest to FIRST, has found that the highest column density cores all have infall motions. We have mapped several starless cores selected from the complete catalog of Lee and Myers (1999) with SCUBA to find their column density. Further observations of these cores in HCO^+ J=3-2, a line particularly sensitive to collapse motions, will determine if a physically meaningful threshold separating quiescent from pre-protostellar cores exists.

Combined Cosmology Programs with SPIRE and Planck HFI

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The FIRST Spectral and Photometric Imaging Receiver (SPIRE) employs arrays of bolometric detectors for sensitive space-borne photometry and spectroscopy at sub-millimeter wavelengths. We envision a joint cosmology program with SPIRE that exploits the rich data set provided by the first Planck/HFI all-sky surveys. The early-release Planck sub-millimeter all-sky survey will detect galaxies at significant cosmological distances, including a fraction that may be gravitationally lensed. Follow-up spectral line surveys with SPIRE will determine the redshift and will probe the interstellar medium in these extremely far-infrared luminous galaxies. Spectral and imaging observations of clusters of galaxies, detected by Planck via the Sunyaev-Zel'dovich effect, may assess relativistic corrections to the S-Z distortion, and probe the contribution from thermal dust emission. Finally, the evolution and clustering of galaxies at high redshift may be probed by fluctuations in the extra-galactic far-infrared background. A P(D) analysis with a deep SPIRE survey will probe the far-infrared background at higher sensitivity and angular resolution over a smaller region of sky, complementing proposed studies of the far-infrared background with Planck.

Project Submillimetron:
The Cryogenic Telescope for the International Space Station

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The Submillimetron is the international project of the space telescope for astronomical studies at the submillimeter and infrared wavelengths using facilities of the Russian segment of the International Space Station (ISS). The concept of the telescope includes a 60 cm mirror cooled to liquid helium temperature and novel type microbolometers arrays using effects of superconductivity. This combination gives unique possibility to realise background-limited sensitivity in the spectral minimum of the extraterrestrial background near frequency 1 THz between peaks of galactic dust emission and CMB. The angular resolution about 1 arcmin, field of view about 1^{o}, and optics are similar to IRAS mission, but more then order of magnitude better sensitivity about 10^{-18} W $Hz^{-1/2}$ and another spectral region permits reveal in full sky survey considerably more new astrophysical objects. The concept of free flying instrument with periodic docking to ISS gives possibility to combine low cost with reliability, refilling, repairment and maintenance. The initiative of the project was done in Astro Space Center of the P.N. Lebedev Institute after discussions with NASA and JPL. Detectors are under development in Chalmers University of Technology, Sweden. The proposal was undertaken to feasibility study in S.P. Korolev Rocket Space Corporation Energia and approved by the Russian Space Agency for the 2-d stage of ISS realisation after years 2004 - 2005.

Far-infrared observations of γ–ray bursts and possibilities with FIRST

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The Infrared Space Observatory observed the field of the γ–ray burst (GRB) of May 8th, 1997 (GRB 970508) with the CAM and PHT instruments on May 21 and 24, 1997 and with PHT in three filters in November 1997. These observations were part of a program to make the first 'rapid response' studies of GRBs at far-infrared wavelengths and were made possible by the rapid and accurate GRB localisation capability of the instruments aboard the Italian-Dutch *BeppoSAX* satellite and the coincidence of ISO being simultaneously in-orbit. A source at $60\,\mu$m (flux in May of 66 ± 10 mJy) was detected near the position of the host galaxy of this γ–ray burst. The source was detected again in November 1997, at a marginally lower flux (43 ± 13 mJy). A Galactic cirrus origin and a stellar origin for the emission can be ruled out on the basis of the infrared colours. The marginal evidence for variability of the $60\,\mu$m flux between May and November is not sufficient to warrant interpretation of the source as transient fireball emission. However, the infrared colours are physically reasonable if attributed to conventional dust emission from a single blackbody source. The probability of detecting a $60\,\mu$m source by chance in a PHT beam down to a detection limit of 50 mJy is $\sim 5 \times 10^{-3}$. If the source is at the redshift of the host galaxy of the γ–ray burst the fluxes and upper limits at wavelengths from $12\,\mu$m to $170\,\mu$m indicate it is an ultraluminous infrared galaxy ($L_{ir} \sim 2 \times 10^{12}\,L_{\circ}$). The star formation rate is estimated to be several hundred solar masses per year, depending significantly on model-dependent parameters. If this source is associated with the host galaxy of GRB 970508, progenitor models which associate GRBs with star-forming regions are favoured. However, further observations of GRB host galaxies in the far-infrared (e.g. with FIRST) could provide further evidence to support the connection between GRBs and star-forming regions.
Many issues regarding the production of the GRB afterglows remain uncertain, despite the advances of the last 3 years. For example, recent theoretical work by Sari & Mészáros has indicated that in a refreshed shock scenario, transient fireball emission should reach a maximum in the far-infrared to mm band a few days after the burst event, with a flux of tens of mJy. Such predictions will be testable with missions such as FIRST.
The prospects for obtaining precise GRB locations while FIRST is in orbit are examined in this paper along with the scientific returns to be expected from the detection of the transient and quiescent far-infrared/submm emission of GRBs.

The structure of cirrus clouds at different galactic altitudes

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Galactic cirrus clouds, often also called high-latitude clouds, span a wide range of physical parameters, some of them consist of pure atomic gas; other are partly molecular. Cirrus clouds can be separated into three classes:

- Low-velocity clouds: distances approx. 100pc, velocity: |v| < 20km/s
- Intermediate-velocity clouds (IVC): distances < 1000pc, velocities: 20km/s < |v| < 100km/s
- High-velocity clouds (HVC): distances > 1000pc, velocity: |v| > 100km/s

The origin of the last two classes is completely unknown. The different distances to the plane of our Galaxy make cirrus cloud ideal targets, to study the formation and structure of molecular clouds in different environments and also to study the structure of our Galaxy and its halo. They might help to answer the questions, how the structure of a molecular cloud influences the formation of stars and how it is linked to the IMF. Much of the structure of a cloud can be deduced from the transition region from H to H_2 and from C^+ over C to CO. As an example we discuss ISO CII observations of a line of sight to a HVC and describe, why spectrally resolved CII observations, as possible with HIFI on board of FIRST, are needed to learn more about the structure of the clouds and about their environment.

Fragmentation in Kinematically Cold Disks

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Gravity is scale free. Thus gravity may form similar structures in self-gravitating systems on different scales. Indeed, observations of the interstellar medium, spiral disks and cosmic structures, reveal similar characteristics. The structures in these systems are very lumpy and inhomogeneous. Moreover some of these structures do not seem to be of random nature, but obey certain power laws.
Models of slightly dissipative self-gravitating disks show how such inhomogeneous structures can be maintained over several galaxy rotations. The basic physical processes in these models are self-gravity, dissipation and differential rotation. In order to explore the structures resulting from these processes on the kpc scale, local simulation of self-gravitating disks are performed in 2D and 3D. The third dimension becomes important as soon as a strong matter clumping causes a tight coupling of the 3D equations of motion.
In order to assess the general relevance of the underlying physical processes we check if they can account for self-similarity. We observe persistent patterns, formed by transient structures, whose intensity and morphological characteristic depend on the dissipation rate. Moreover some of our simulations reveal first signs of power-law relations.

Water abundance: first interferometer maps of $H_2^{18}O$ and other water isotopes towards hot molecular cores

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Spectral lines of Water are difficult to observe from ground-based telescopes. Observations of the isotopic species $H_2^{18}O$ with single dish radio-telescopes gave estimates of water column densities towards hot molecular cores (see e.g. Jacq et al. 1988 A&A 199, L5; Gensheimer et al. 1996 A&A 314, p. 281). However, the low spatial resolution of these data hampered the interpretation of the results. We then decided to observe some of these sources with the IRAM interferometer and we present here preliminary results obtained towards Orion IRc2. We have mapped Orion in the following transitions : $H_2^{18}O$ (203.4 GHz) and HDO (80.6 GHz) with five antennas in the array; HDO (225 GHz) and NH_2D (110 GHz) with four antennas. First analysis is ongoing and shows the clumpiness of the gas cloud with the bulk of the emission being clearly resolved by the interferometer.

Pre-Protostellar Core Properties from Far-IR Observations

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We report the results of an analysis of pre-protostellar core properties derived from the Infrared Space Observatory (ISO) observations at 100, 160, and 200 microns. We use a simple two-temperature grain model to separate the line of sight components into core and halo contributions. Where available we have combined the ISO data with ground based continuum maps at 1.3 mm. In our analysis of three cores, L1498, B133, and B68 we derive the column density distribution, mass, density profile and dust temperature. The derived core properties are compared with various theoretical models of static and dynamic cores, including the effects of magnetic fields. Comparison with molecular line maps allows us to derive the degree of depletion onto grains, something we find to be quite prominent in these sources. We also discuss the role of FIRST in extending this approach for understanding these prestellar cores.

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Hot Dust Around Warm Stars in the Trifid Nebula

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The Trifid Nebula is a young "Pre-Orion" HII region, undergoing a burst of star formation. We report on mid-IR observations of the central region in the Trifid nebula, carried out with ISOCAM in the LW4, LW7, LW10 filters and in the low resolution spectroscopic mode provided by the circular variable filter. Analysis of the emission of indicates the presence of a hot dust component (500 to 1000 K) and a warm dust component at lower temperatures ($\sim 150-200$ K) around several members of the cluster exciting the HII region, and other stars undetected at optical wavelengths. Complementary VLA observations suggest that the mid-IR emission could arise from a dust cocoon or a circumstellar disk, evaporated under the ionization of the central sources and the exciting star of the nebula. In several sources the $9.7\mu m$ silicate band is seen in emission. Around one young stellar source we found the presence of crystalline silicates in the circumstellar dust.

Quiescent Giant Molecular Cloud Cores in the Galactic Center

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We have used the Long Wavelength Spectrometer aboard the Infrared Space Observatory to map the far-infrared continuum emission (45–175 μm) toward several massive Giant Molecular Cloud (GMC) cores located near the Galactic center. The observed far-infrared and submillimeter spectral energy distributions imply low temperatures (~13–20 K) for the bulk of the dust in all the sources, consistent with external heating by the diffuse interstellar radiation field (ISRF) and suggest that these GMCs do not harbor high-mass star-formation sites, in spite of their large molecular mass. Observations of far-infrared atomic fine structure lines of CII and OI indicate an ISRF enhancement of ~1000 in the region. Through continuum radiative transfer modeling we show that this radiation field strength is in good agreement with the observed far-infrared and submillimeter spectral energy distributions, assuming external heating of the dust. Spectroscopic observations of millimeter-wave transitions of H_2CO, CS, and $C^{34}S$ carried out with the Caltech Submillimeter Observatory and the Institut de Radio Astronomie Millimétrique 30-meter telescope indicate a gas temperature of ~80 K, significantly higher than the dust temperatures, and density of $\sim 1\times10^5$ cm^{-3} in GCM0.25+0.01, the brightest submillimeter source in the region. We suggest that shocks caused by cloud collisions in the turbulent interstellar medium in the Galactic center region are responsible for heating the molecular gas. This conclusion is supported by the presence of widespread emission from molecules such as SiO, SO, and CH_3OH, which are considered good shock tracers. We also suggest that the GMCs studied here are representative of the "typical", pre-starformation cloud population in the Galactic center.

FAR IR SPECTROSCOPY OF PRE-MAIN SEQUENCE STARS: The Lesson Learned from ISO and Perspectives

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We have recently analysed the ISO-LWS spectra (45-200 μm) of two classes of Pre-Main Sequence objects, the Herbig Ae/Be (HAEBE) and the FU Orionis stars. ISO-LWS has provided an unbiased view of the neighbourhood of the central object by sampling the physical scale ($\approx$ 80 arcsec) where the interaction with the closeby environment is taking place. The HAEBE sample, composed by 11 sources, shows relevant contributions from [OI] 63, 145 μm and [CII] 158 μm emission, mainly due to photodissociation excited by the star itself, given its early spectral type. In sources expected to have higher density circumstellar material, molecular emission is detected in form of CO and OH transitions. By comparing the molecular line cooling with model predictions, photodissociation, possibly in a clumpy medium, is suggested as the dominating excitation mechanism. Different results come from the far IR spectroscopic survey of 7 FU Ori objects. Again [OI] and [CII] lines are commonly observed in all spectra, but the observational novelty is the presence, in most of the sources, of the [NII] transition at 122 μm, which is not detected in other objects in a similar evolutionary phase. The interpretation of the observed spectra requires the presence of two components: well localised J-shocks, responsible for the [OI] emission, and an extended low density ionised medium produced by UV photons from the disc boundary layer, responsible for the [NII] and [CII] emission. A few molecular lines (from CO, OH, H_2O) associated with cold and dense peaks have intensities in good agreement with the proposed scenario. Other ionic lines at higher ionisation stages (*e.g.* [OIII]) are revealed in few HAEBE and FU Ori stars; while in the former case they are associated with the objects having spectral types earlier than B0, in the latter class they only trace the presence of nearby HII regions.

These far IR surveys have pointed out how remarkable aspects remain still unaddressed and have originated new questions which can be answered by using the capabilities offered by FIRST. In particular we will emphasize the importance of a better spatial resolution to study the internal structures of the detected PDR by tracing the transition zones $C^+/C^0/CO$, then clarifying whether or not clumpiness is an important ingredient. Moreover we discuss how to explain the lesser than expected [OI]63μm/[OI]145μm observed line ratios by studying whether this large scale behaviour stems from intrinsic properties of the emitting gas, or results from averaging different emission *vs* absorption components. Finally, ISO-LWS missed the fine structure transition of [NII] at 205μm instead observable with the instrumentation on board FIRST. We present diagnostic diagrams able to predict, by using the [NII] line pair, the electron density in the N^+ volume and the fractional ionisation in the environment around FU Ori objects, allowing to verify our hypothesis about the [NII] excitation mechanism.

High rotational lines from the Orion BN/KL star forming region

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We present observations of the closest region of high mass star formation, Orion BN/KL, performed in Fabry-Perot mode with the Long Wavelength Spectrometer (LWS) on board the Infrared Space Observatory (ISO). We detected the CO rotational transitions from Jup = 15 to Jup = 49. A LVG analysis of the line fluxes allows to distinguish three main physical components with different temperatures, densities and column densities: the photodissociation region (PDR), the low velocity outflow (plateau), and a hot and dense gas component. The latter exhibits broadened lines for the levels $J_{up} > 32$ and is thought to be due to shocked gas in a high velocity outflow. The Far Infrared Space Telescope (FIRST) instruments, particularly the spectrometers, will permit the spectral and spatial separations of the PDR and the plateau components, unresolved with ISO, and characterise more precisely the Orion BN/KL star forming region.

C^+ in LINERs Galaxies

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Within the framework of Nuclear Activity in Galaxies, LINERs still constitute a matter of debate. No general consensus does exist about the nature of these galaxies. From an IR perspective, after the work of Kim and colaborators, it became clear that meanwhile nuclear activity increases with far IR luminosity and starburst-like events decrease, the proportion of LINERs remains constant no matter which luminosity they have.
To get some insight about the nature of LINERs we started a project by using the ISO database to characterize the FIR properties of these rather enigmatics galaxies. From the large recopilation presented in the Multifrequency Catalogue of LINERs (Carrillo, Masegosa et al 1999) 69 objects have been observed with ISO. In this work we report the results obtained for the ISO LINER sample on the C^+ line, the most bright line at IR frequencies. The implications for searching high redshift galaxies with the new forthcoming instrumentation are discussed.

FIRST Observations in Low-Intermediate Mass Star Forming Regions

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JCMT polarimetry toward a filamentary cloud in Orion A reveals a pattern predicted for a helical magnetic field configuration. The radial density profile of r^{-2} discerned from intensity data at 850 μm is also predicted for a helically threaded cloud since additional support is provided by the magnetic field. Several other filamentary clouds in Cygnus also exhibit the r^{-2} density profile. However, many filamentary clouds (e.g. those in Taurus) are too large to map substantially with SCUBA. Gas maps are useful for mapping large scale features, but continuum maps are required to identify the dusty protostellar envelopes or prestellar cores. Since FIRST will probe shorter wavelengths than current instrumentation with better resolution, it will be invaluable for extensive mapping of cloud structures as well as identifying the cores within. The resolution will be too poor to study the inner protostars or disks in continuum, but the large scale maps will more than compensate for this limitation. SCUBA2 will provide a strong followup instrument for polarimetry as well.

Simulating galaxy surveys with FIRST (PACS & SPIRE)

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The next generation of submillimetre/millimetre instruments will provide us with a closer insight into the mechanisms that rule galaxy formation. As the brightest starbursts are thought to be heavily obscured at optical wavelengths, the opening of this new window will complement the present observations, and enable a detailed investigation of the hierarchical merging of galaxies at remote epochs. In this context, we will present preliminary results of simulations currently developed for deep galaxy surveys with FIRST.
N-body simulations of galaxy mergers are being developed to produce realistic morphologies and star formation histories. A Schmidt law is used to account for the evolution of the stellar and gas content of each particle. These simulations will be gathered in a library, including the temporal information with a timestep of 10 Myr. We then build consistent spectra, essentially based on the dust modelling of Desert et al. (1990), accounting for this star formation history at each resolution element of the simulations. These morphologies are included in the framework of the GALICS hybrid model of hierarchical galaxy formation, which reproduces the main observational constraints. We will present synthetic maps with the characteristics of the FIRST PACS/SPIRE instruments and discuss the optimal strategy for deep surveys complemented with the ground-based ALMA project.

The abundance of small dust particles in cirrus clouds: the impact of turbulence and the implication for the thermal balance of the gas

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We present a study of the impact of the gas dynamics on dust properties based on 21 cm and ISOCAM (between 5 and 18 microns) observations of a Galactic cirrus located in the Ursa Major constellation. The comparison of these two observations revealed strong abundance variations of the small dust particles in a Hi filament. Using the spectral information provided by the 21 cm line emission we were able to trace the dust abundance of the Hi as a function of velocity. We have found that the small dust particles are up to ten times more abundant in a filament in comparison with the more diffuse Hi that surrounds it. Furthermore, this filament is characterized by a strong transverse velocity gradient (10 km/s/pc) that can be attributed to a rotation. The particular kinematics of this filament, that could be related to a turbulent vortex, may be at the origin of this dust abundance variation via enhanced grain-grain collisions.

Recently, it as been suggested by Falgarone & Puget (1995) that the dissipation of the turbulent energy, that occurs in vortex, could have an impact on the heating of the gas, on the dust size distribution, on the formation of molecules and therefore on the global evolution of the diffuse ISM. The filament observed here could be an observational evidence of such a process in the Hi gas. FIRST will allow to make an important step further in the characterization of the impact of turbulence of the ISM evolution, by providing high resolution informations on the structure, the kinematics and the physical conditions of such diffuse structures. For example, by taking advantage of the sensitivity and the high spectral resolution of the HIFI instrument, it will be possible to trace the C^+ and CI emission in diffuse clouds, and study the temperature, the pressure and the carbon abundance as a function of velocity. By comparing these observations with dust emission, we will be able to constrain the thermal balance of the diffuse medium.

SPICA (Space Infrared Telescope for Cosmology & Astrophysics): a mission optimized for mid- and far-infrared astronomy

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We present a conceptual design of the infrared astronomical mission SPICA, which is a unique mission with a cooled, large telescope.
We propose to cool a 3.5 m class telescope down to 4.5 K by combination of moderate-size mechanical cryogenic coolers with the help of effective radiative cooling. In other words, the SPICA will not carry huge amount liquid Helium, and thereby we can reduce the total weight dramatically. We plan to use the Japanese H-IIA launching vehicle, which can put this class of mission into a halo orbit around one of the Sun-Earth Lagrangian libration points (L2), where radiative cooling becomes very effective.
The cooled, large telescope makes the SPICA mission optimum for high-resolution mid- to far-infrared observations with unprecedented sensitivity. We propose to cover the wavelength range of 5 - 200 μm with two focal plane instruments.
Since the telescope of the SPICA is cooled to 4.5 K, the SPICA mission is complementary with FIRST, which focuses longer wavelength region with a warmer telescope.
The target launch year of SPICA is 2010.

L134N revisited

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L134N is a very cold, starless and nearby dark cloud which has attracted much attention from the astrochemists in the past. They have been using it as an oxygen-rich reference to test their models in parallel with TMC-1, the other, but carbon-rich, reference. However, our knowledge of the cloud temperature, structure, and various species abundances relies largely on the work by Swade (1987, ApJS 71, 219 & ApJ 345, 828) which suffers from low signal-to-noise $C^{18}O$ and CS maps and limited excitation analysis. While FIRST will probably find many new species in this cloud, it is time to revisit completely this source in order to interpret correctly the FIRST results to come. We have thus made a complete survey of CO, ^{13}CO, $C^{18}O$, $C^{17}O$, CS, $C^{34}S$, SO and ^{34}SO species with the NRAO 12 m and CSO 10 m to assess the fundamental properties of this cloud. Preliminary results are reported here.

Atomic Carbon in Twin Peaked Starburst Galaxies

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This poster will compare [CI] data with multi-line CO data for the two nearby barred starburst galaxies, M82 and M83. Both galaxies exhibit a twin-peak morphology in CO, but in both cases the [CI] maps appear brighter in one lobe that the other. We will discuss possible mechanisms for this in light of the contrasting CO data, and we will also discuss the new information that will be available from observations of these galaxies in [CI] and C^+ using HIFI.

Signposts of massive stellar evolution onto the ambient neutral gas. The case of NGC 2359

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NGC 2359 is an optical nebula excited by the powerful wind and the radiation of the Wolf-Rayet (WR) star HD 56925 (= WR7). Based on observations of the HI hyperfine transtion at 21 cm and mm observations of CO and 13CO, we have drawn the history of the interaction of HD 56925 with the surrounding neutral material. The main sequence phase of this star has carved a huge HI bubble of about 50 pc, which is expanding at 12 km/s. On the other hand, the molecular emission around the nebula shows signs of interaction with the radiation field and the stellar wind during a previous RSG/LBV phase and probably the WR phase. There is a region with rather hot (80 K) gas almost coincident with the optical nebula, surrounded by more opaque and dense molecular gas. We think that the gas is beeing excited by the radiation field of the star and by shocking produced during the expansion of the WR bubble. This region is a good candidate to make mm, sub-mm and infrared observations of spectroscopic lines to determine the physical and chemical effects of the evolution of massive stars onto the interstellar medium.

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The Galactic center Interstellar Medium: from ISO to FIRST

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With the purpose of investigating the heating mechanisms of the Galactic center (GC) molecular clouds, we have studied a sample of 18 clouds distributed all along the CMZ (Central Molecular Zone) at millimeter and infrared wavelengths using ISO and IRAM-30m telescopes. The clouds were selected from the CS or SiO large scale maps of the GC region. ISO has shown the complexity of the GC "molecular" clouds detecting, not only large column densities of warm molecular gas (H_2) without associated warm dust, but emission of atoms and low excitation ions (CII, OI, SiII,...) that should arise in shocked or photon-dominated regions (PDRs). In addition, ISO has also detected emission from ions like SIII, NeII, ArII, or NII (in some clouds we have even detected NeIII and OIII) that should arise from HII regions that were previously unsuspected due to the non-detection of Hydrogen recombination lines at millimeter wavelengths.
In our contribution we will review the ISO results on the large scale study of the GC interstellar medium. We will also look forward to the FIRST satellite and discuss how it will help to understand the energetics of the GC. The high spectral and spatial resolution that the HIFI instrument will achieve, would be of great interest to study the morphology and kinematics of the ionized material and the warm molecular gas.

MRCI/CASSCF study of the structures and spectroscopic properties of C_3, C_3H+ and C_3H

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In this paper, we study the molecular stable geometries and some spectroscopic properties of C_3, C_3H+ and C_3H with ab initio calculations at the MPX (X= 2, 3, 4), CASSCF and MRCI levels using extended basis set. The main purpose of the work is the determination of the vibrational levels corresponding to the large amplitude motions. The potential energy surfaces for the lowest electronic states are calculated close to the equilibrium structures. C_3 and C_3H+ ground electronic state are singlet states preserved during the protonation process. The ground electronic state of C_3H is a $^2\pi$ doubly degenerate. This radical present strong Renner-Teller vibronic effect that requires non-conventional Hamiltonians for the determination of the spectral lines.

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A Monte Carlo code for radiative transfer in molecular lines: Application for CO and water lines in circumstellar shells.

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A Monte Carlo approach (Bernes ,1979, A&A 73, 67) is well suited to study the non-LTE, multi-level radiative transfer in molecular lines, because it is based on the statistical interpretation of the molecular excitation processes due to both radiative transfer and collisions. We have applied the standard Monte Carlo technique to investigate the radiative transfer in molecular lines in circumstellar shells where physical conditions can vary significantly over the region under study (variable mass loss rate, transition from collisional to radiative excitation mechanism, continuum dust radiation, etc.). This code allows us to treat an arbitrary geometry, velocity and density distribution. Tests have been performed for spherically symmetric circumstellar shells with uniform velocity and density structures and comparison with Large Velocity Gradient solutions for carbon oxide and water molecules are presented.

Water cooling in protostellar objects: results of the ISO-LWS and the future role of FIRST

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We review the results of the far–infrared emission line spectra of the water molecule obtained with the Long Wavelength Spectrometer onboard of ISO on a sample of protostellar and pre-Main Sequence sources.
Water was expected to play an important role in the cooling of shock-excited regions associated with the star formation process. Contrary to the current C-type shock models, ISO has found that in most of the sources water is not the dominant coolant and has much lower abundances than expected. These results have been recently confirmed by the observations made by SWAS. We will outline here the possible explanations.

FIRST, with its high spatial and spectral resolution with respect to ISO, will be able to identify and disentangle different emitting regions allowing an accurate study of shock excited regions. Moreover, due to the improved sensitivity, statistically significant samples of protostellar and pre-Main Sequence objects will be observed.

Preliminary Thermal Design Analysis of Large-Sized Infrared Telescope for SPICA

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An ambitious spacecraft mission named SPICA is intended to make high-resolution infrared astronomical observations. The spacecraft, which is launched by the H-IIA launch vehicle, is finally swung into a halo orbit around the Sun-Earth Lagrangian liberation point 2 (S-E L2). The telescope of 3.5 m diameter is required to keep at 4.5 K in the inside and 1.5 K for a far-infrared observation instrument on the focal plane over a long period of mission operations. This telescope system is radiatively cooled down and then mechanically refrigerated without cryogens. It is, therefore, crucial to achieve practical and efficient thermal design for mission success. In this paper, we carry out axial and radial temperature predictions in some cases where different types of the H-IIA payload fairing are used, considering the aperture ration, the radiation area, the shield thickness and materials as design parameters. Finally we propose an optimum structure of this infrared telescope.

Dust and Gas Temperatures in Orion B

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The temperature of the Interstellar Medium is one of the fundamental physical parameters needed to understand its evolution, and especially star formation. It is also very difficult to constrain, requiring time-consuming observations that are often model-dependent.
We present millimetre-wave formaldehyde line data that allow us to derive the temperatures of gas cores in the high-mass star forming region Orion B. We compare this data with our submillimetre continuum maps of the region, and discuss the potential of FIRST for measuring dust and gas temperatures in regions such as this.

Modelisation of the PDR in the HII region W49N

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The W49N HII region is one of the most luminous regions of active star formation in the Galaxy. We performed ISO-LWS observations of the [OI] (63μm and 145μm) and [CII] (158 μm) lines seen in emission and the OH (119 μm, 53 μm and 84 μm) lines seen in absorption towards this region. We also used CO and its isotopes in the first two transitions, which are observed in the same beam than the LWS one.

We first used an LVG model in order to reproduce the different fluxes in those lines and estimate physical parameters like column densities, temperature and densities. The cooling lines in this region present anomalously low heating efficiency and 63/157 ratio suggestive of an inhomogeneous medium. Furthermore, the geometrical complexity of this source, with 7 distinct ultra-compact HII regions powered by O5-O8 stars in the W49N core surrounded by 3 distinct molecular clouds, requires the use of models more sophisticated than face-on plane-parallel slabs ones. Such PDR models have been developed (Spaans & van Dishoeck 1997) and used in our case in order to determine the physical conditions in this clumpy medium.

We will present a comparison of the intensities in the lines with many similar region to determine how much is the HII region W49N an extreme source. Finally, new observations with a higher sensitivity and spectral resolution that will be attain by the 3 focal plane instruments of FIRST are clearly needed in order to probe the physics, kinematics and energetics of star forming regions through their cooling lines.

High resolution ISO-LWS observations of [OI] in absorption towards Sagittarius B2

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The 63 μm fine structure line of atomic oxygen has been observed towards Sagittarius B2 at high resolution by the ISO *Long Wavelength Spectrometer*. Absorption is seen both due to Sgr B2 itself and from material in the line of sight.

The contribution to the absorption by [OI] associated with diffuse atomic clouds in the line of sight is predicted. Published HI 21 cm observations are used with an assumed galactic gradient for O/H to calculate the [OI] optical depth in these clouds. When these components are convolved with the LWS spectral response function they are found to account for only a small fraction of the total observed absorption.

The discrepancy in absorption is made up by fitting [OI] optical depths in cold molecular clouds. H_2CO 6 cm observations from the literature are used to give the line widths and velocities of molecular components. [OI] optical depths are then fitted to the observed absorption. Column densities of [OI] are calculated from these optical depths giving the total column density in the line of sight molecular clouds as 1.1×10^{20} cm^{-2}.

ISO observations of M31 : the need of FIRST.

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We present ISOCAM observations of M31, the Andromeda galaxy. Images (raster) and spectra (cvf) have been taken in two peculiar regions of the galaxy: the center and a part of the molecular ring. We discuss the characteristics and spatial distribution of dust which present major differences with the Milky Way. Far-IR observations with IRAS and ISOPHOT show that the bulk of dust is cold with the brightest region NW to the center. We conclude on the need of FIRST observations of this galaxy.

Structure of the MIR emission in the circum-nuclear regions of active and/or starburst galaxies

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We report a study of the circum-nuclear regions of a sample of galaxies with active nucleus and/or star-forming complexes using ISO data and information from other wavelengths. The emphasis is on the knowledge that could be gathered from observations at mid-infrared wavelengths, in particular PACS imaging and integral field spectrometry, for the study of the circum-nuclear regions in galaxies at z~0. We also show how some of our reduction techniques successfully applied to ISO data could be useful for PACS data.

The SIRTF Mission

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The Space Infrared Telescope Facility (SIRTF) is scheduled for launch in 2002. It will place a cryogenic 85 cm diameter telescope in a trailing heliocentric orbit that drifts away from the Earth at 0.1 au/yr.

Three instruments will provide very sensitive IR imaging in a 5x5' FOV from 3.5 to 160 microns and low and medium resolution IR spectroscopy from 5 to 40 microns.

Dust distribution in Galactic compact HII regions
ISOCAM view and the promise of FIRST

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I present the results of an ISOCAM study, between 3 and 12 microns, of the dust distribution in five Galactic compact HII regions, Sharpless 61, 138, 152, 156 and 186.

The images show the distribution of emission in the unidentified infrared bands centred at 3.3, 6.2, 7.7, 8.6 and 11.3 microns and of the distribution of the continuum emission. The distribution of the band emission is spatially correlated with the 2.12 microns emission from molecular hydrogen, indicating a relation between the two.

I also present the perspectives of this program using FIRST.

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