Stormy Cosmos: The Evolving ISM from Spitzer to Herschel and Beyond

1-4 November 2010, Pasadena, CA

http://www.ipac.caltech.edu/ism2010/

Poster Abstracts

Astrochemistry of Shocks and Other Dynamic Interstellar Processes

Tatyana N. Brusentsova (University of Central Florida)
Temperature-dependent Far-IR Spectroscopy of Various Mineral Groups: Providing Laboratory Data for Herschel
To aid in interpreting data from Herschel Space Observatory Photodetector Array Camera and Spectrometer (PACS), we have collected mass absorption coefficient spectra in the wavelength range 15 to 250 micron of micron-sized powders for more than 140 mineral species representing various mineral groups. Mineral groups investigated included nesosilicates (olivines, garnets, phenakite), inosilicates (pyroxenes, pyroxenoids, amphiboles), sorosilicates, cyclosilicates, tectosilicates (silicas, feldspars), phyllosilicates, carbonates, sulfides, and oxides. The mineral samples were selected from AMNH mineral collection, chemical and crystallographic identity of all minerals was confirmed by means of electron microprobe and grain and powder XRD. Samples were ground to micron dimensions and the micron size distribution was ensured by Stokes settling, verified by scanning electron microscopy. Milligram quantities of mineral sample were dispersed in polyethylene powder and melted into pellets. Spectra were collected using a Fourier spectrometer with globar source, mylar beamsplitter, and a 4 K bolometer. Temperature dependence of the spectra down to 15 K revealed sharpening and blue-shifts of the characteristic absorption lines, and in some cases, resolution of additional features not seen at room temperature. Mineral spectra in the far-IR region are highly characteristic of mineral group, crystal structure and chemical composition. The spectral data obtained in this study, together with the accompanying mineral characterization data, will be added to Planetary Data System database to be used for mineral identification in cosmic dust populations, based on far-IR emission spectra of collected by Herschel and similar space IR missions.

Jan Cami (University of Western Ontario)
The Detection of Fullerenes in the Planetary Nebula Tc 1.
As soon as chemists discovered fullerenes in laboratory experiments on Earth, it was suggested that they would form in the outflows of carbon stars, and survive abundantly in the interstellar medium. However, conclusive evidence for even the presence of fullerenes in space has long been lacking, in spite of several dedicated searches. We recently analyzed the very unusual Spitzer-IRS spectrum of the planetary nebula Tc 1, and concluded that it shows the unmistakable signatures of the fullerene species C60 and C70. Whereas there is little doubt about the identification of these species, the environment in which they reside raises several questions about their formation and

excitation mechanism(s), and about the overall galactic fullerene abundance. In this poster, I will first present our case for the identification of fullerenes in Tc 1 and describe the peculiar environment in which we found them. I will then briefly address these open questions and the possible implications for the physics and chemistry of interstellar and circumstellar environments.

Sarah M. Fortman (OSU)
How Complete are Astrophysical Catalogs?
Sarah M. Fortman, Ivan R. Medvedev, Christopher F. Neese, Frank C. De Lucia
It is well known that there are many unidentified lines in astrophysical spectra. There is a strong consensus that many of these lines arise from difficult to analyze excited vibrational/torsional states of a small number of relatively abundant molecules, the astrophysical weeds. For eight of the most important of these species, we will compare calculations based on the distributions in energy of their excited vibrational states with laboratory observations. We will also discuss strategies for archiving and disseminating the experimental results. Particular attention will be given to strategies appropriate for blended and overlapping lines.

Harshal Gupta (JPL)
Herschel Observations of EXtraOrdinary Sources: Detection of OH^+ and H_2O^+ toward Orion KL
The reactive molecular ions, OH^+, H_2O^+, and H_3O^+, key probes of the oxygen chemistry of the interstellar gas, have been observed toward Orion KL with the Heterodyne Instrument for Far Infrared on board the Herschel Space Observatory. All three N = 1−0 fine-structure transitions of OH^+ at 909, 971, and 1033 GHz and both fine-structure components of the doublet ortho-H_2O^+ 111 - 000 transition at 1115 and 1139 GHz were detected, and an upper limit was obtained for H_3O^+. OH^+ and H_2O^+ are observed purely in absorption, showing a narrow component at the source velocity of 9 kms^{-1}, and a broad blue shifted absorption similar to that reported recently for HF and *para-*$H_2^{18}O$, and attributed to the low velocity outflow of Orion KL. We estimate column densities of OH^+ and H_2O^+ for the 9 kms^{-1} component of 9 ± 3 * 10^12 cm^{-2} and 7 ± 2 10^12 cm^{-2}, and those in the out flow of 1.9 ± 0.7 * 10^13 cm^{-2} and 1.0 ± 0.3 10^13 cm^{-2}. Upper limits of 2.4 * $10^{12}cm^{-2}$ and 8.7 * $10^{12}cm^{-2}$ were derived for the column densities of ortho and para-H_3O^+ from transitions near 985 and 1657 GHz. The column densities of the three ions are up to an order of magnitude lower than those obtained from recent observations of W31C and W49N. A higher gas density, despite the assumption of a large ionization rate, may explain the comparatively low column densities of the ions.

Antoine Gusdorf (Max Planck Institute for Radioastronomy)
From Spitzer to Herschel: Observations and Modeling of Molecular Emission in Shock Regions
In this poster, I will present observations and models of H2 and SiO emission in regions of shocks such as BHR71 (bipolar outflow) or IC443 (Supernova remnant). The observations were performed using respectively Spitzer and APEX telescopes, and their comparisons with models result in constraints on shock model and pre-shock region parameters. In turn, these constraints make it possible for us to deliver water emission

predictions, to be compared with Herschel observations. BHR71 and IC443 are indeed to be observed by Herschel, in the respective frames of the WISH and WADI key programs.

Thomas Jarrett (IPAC/Caltech)
Mid-Infrared Spectroscopy of the Ultra-luminous X-ray "hypernova" candidate MF16 in the nearby galaxy NGC 6946
We present Spitzer Space Telescope mid-infrared observations of the brightest x-ray and [FeII] (1.64 um) source in the nearby starburst galaxy NGC6946. MF16 is ultra-luminous in X-rays, ~10^40 erg/s, speculated to be the result of a hypernova event; it has also been suggested that it is a high-mass binary system, or even an intermediate-mass blackhole with jet-shell interaction. From Spitzer imaging we know that the source lies within a dense medium, and moreover displays an asymmetric radio morphology. The extraordinary [FeII] emission we detect is most consistent with a massive blast-wave "hypernova" and gamma-ray burst event, possibly resembling the W49B SNR. We investigate the broad MIR H2 lines to probe the shock-cloud interaction, and hope to use the full low-res and high-res IRS spectral mapping to decode this enigmatic and powerful source.

Els Peeters(1,2), Jacqueline Otaguro(1), Patrick Cookson(1), Xander Tielens(3), Mark Wolfire(4), Lou Allamandola(5)
1 University of Western Ontario, Canada
2 SETI Institute, USA
3 Leiden University, The Netherlands
4 University of Maryland, USA
5 NASA Ames Research Center, USA
The Spatial Behavior of the PAH Emission Bands.
A key result in the observational studies of PAHs is that their mid-IR bands show clear variations in intensities and profiles and that these variations depend on the object type, the (hardness of the) radiation field, the electron density, the effective temperature and the type of environment (i.e. CSM versus ISM). However, from the molecular spectroscopy point of view, intrinsic spectra of PAH molecules are determined by their charge state, size, precise molecular (edge) structure, and their temperature (vibrational energy content). Thus, the observed variations in the PAH bands are controlled by both the local physical conditions and the constituents of the PAH population. However, how the PAH population is altered in a given environment, how PAHs evolve throughout their life and, the underlying cause for these observed spectral variations is currently not well understood.

Here, we present Spitzer-IRS spectral maps for three spatially extended sources which sample distinct stages in astronomical PAH development: a reflection nebula, an HII region and a planetary nebula. Aside from the main PAH features, we detect many weaker PAH features, molecular hydrogen lines, and fine-structure lines. The detailed characteristics of the PAH features (including the weaker bands) vary spatially across the extended sources and from source to source. These spatial distributions are synthesized to categorize the PAH bands in different groups: all members of a single group exhibit similar spatial behavior across the spectral maps. We interpret these different groups and their different spatial behavior in terms of variations in PAH characteristics such as e.g. size, charge and structure with the changing environment across the spectral maps.

Jorge Pineda (Jet Propulsion Laboratory)
Dense Molecular Clouds and PDR Conditions in the Inner Galaxy from [CII], [CI], and CO Observations
We present observations of (sub)mm and FIR spectral lines of the main carbon species, CII, CI, and CO, originating from the HI, and H2 layers, and the CO cores, in molecular clouds illuminated by an external FUV radiation field. These observations can be used to understand the effects of newly formed stars on their interstellar environment and characterize the physical and chemical state of the star-forming gas. The CII data are from Galactic Observations of Terahertz C+ (GOTC+), a Herschel Key Project devoted to studying the [CII] emission in the Galactic plane using the HIFI instrument. The CO and CI are obtained from the Mopra and NANTEN2 telescopes, respectively. We combine the [CII] data with observations of the [CI] 609um, and CO(1-0) to derive physical conditions of the line-emitting gas. Together these three carbon species constrain the cloud and PDR conditions, including temperature, density, and radiation field. In four Galactic lines-of-sight, we identify 21 velocity components (clouds) showing [CII], [CI], and CO emission. We compare these observations with the results of a grid of clumpy PDR models to constrain the FUV radiation field and H2 volume density. We find that most of these clouds are exposed to FUV radiation fields lower than chi_0=100 and have H2 volume densities larger than 1e4 cm^-3; in addition there are five clouds with lower FUV fields of the order of the average interstellar field and densities of about 10^3 cm^-3 and one cloud is exposed to a strong FUV field between CHI_0=10^5-10^6 with high H2 volume density of 1e5 cm^-3, therefore likely associated with a massive star-forming region.

Ciro Pinto (SRON)
Chemical and Physical Structure of the Interstellar Medium
In the last decades high-resolution X-ray spectroscopy has become a powerful diagnostic tool for constraining the chemical and physical properties of the interstellar medium (ISM). Through the study of the X-ray absorption lines in the spectra of background sources it is possible to probe the different gas phases of the interstellar medium of our Galaxy and to estimate the abundances of the most abundant elements, such as oxygen, iron, and neon. We present our results on high-quality spectra taken with the Reflection Grating Spectrometer onboard XMM-Newton along different lines of sight with a detailed analysis of the absorption features due to the neutral and ionized gas of the ISM, as well as absorption by dust (Pinto et al. 2010). We found significant deviations from Solar abundances, especially when the line of sight points towards the inner regions of the Galaxy. Most elements appear to be less abundant in the outer region of the Galaxy, while in the innermost regions most of the abundances exceed the Solar values. Interestingly, abundances, as determined in the X-rays, seem to follow the metallicity gradient in the Galaxy measured at longer wavelength. The bulk of the interstellar gas is neutral. Moreover, a significant fraction of the interstellar matter is found in dust grains. We show how the fine structure of the absorption edges contains clues on the chemical composition of the dust grains.

Naseem Rangwala (University of Colorado)
Characterizing the Molecular ISM in Extreme Star-Formation Environments: a Starburst (M82) and a ULIRG (Arp 220)

We present spectroscopic observations (195 - 670 microns) of a nearby starburst galaxy, M82, and a local ULIRG Arp 220, measured using the Spectral and Photometric Imaging Receiver (SPIRE) on the Herschel Space Observatory. The spectrum of M82 is dominated by the CO rotational line ladder from J = 4-3 to J = 13-12. The Arp 220 spectrum shows strong water emission lines, which have a total luminosity comparable to its CO ladder. We show detections of H2O+ and HF lines in Arp 220, which have not been observed previously in extragalactic sources. The strengths of the CO lines place fundamental constraints on the physical properties of the molecular gas. Combining our high-J CO lines with low-J CO lines measured from the ground we have a total of 13 lines per galaxy (an unprecedented number), and thus using our non-LTE modeling we obtain tight constraints on the kinetic temperature, density, column density and mass of the molecular gas. Furthermore, we also investigate the presence of multiple components (cold and warm) in the molecular gas. Our results indicate a surprisingly large quantity of very warm (~500 K) molecular gas in M82, and possibly in Arp 220. The modeling also produces the line optical depths, excitation temperature and level populations providing insight into the excitation mechanism. We will present and compare the results from non-LTE modeling of the CO ladder for the two galaxies.

Raghvendra Sahai (JPL)
Ballistic Stellar Interlopers Sculpting Interstellar Clouds

Star formation complexes typically display YSOs spread over a variety of ages (10^6-10^7 years) and have considerable substructure, with clumpy molecular clouds distributed over an extended volume comparable to that in which the young stars are found. It shouldn't be surprising, then, that some of the fast-moving stars in these complexes are moving through clouds far from their birth sites, and undergoing energetic interactions with the gas in those clouds via their radiation, winds and gravity. Yet, this important phenomenon has not previously been studied systematically, presumably due to the lack of known objects in this class and because star formation studies have generally focused on embedded protostars still actively accreting from their natal clouds. From an HST survey, we have serendipitously discovered a small number of such "ballistic stellar interlopers" - stars which lie at the tips of elongated nebulosities, generally showing cometary or bow-shaped structures. These objects are likely intermediate/massive stars drifting into, and undergoing observable interactions with clouds that are far from their birth sites. We report the results of a multi-wavelength study of these interlopers, including (1) identification and characterization of the dense clouds with which the interloper stars are interacting, via mm-wave molecular-line mapping, (2) detection of shocked gas in the stellar wind-cloud interaction via long-slit spectroscopic observations of shocked H2 ro-vibrational line emission, (3) Adaptive Optics near-IR imaging to locate the interlopers within the bow-shocks, and (4) radio-continuum observations to look for photoionized gas and thus determine if the interlopers are massive or intermediate-mass stars. We propose to follow up our discovery with a systematic HST survey for these interlopers in order to obtain a large sample with which to study the nature of the interloper stars and their winds, and their interaction with the ambient interstellar clouds.

Ravi Sankrit (SOFIA/USRA)
Spitzer Observations of the XA Region in the Cygnus Loop Supernova Remnant
We present observations obtained with MIPS and IRS of a bright shock excited region in the Cygnus Loop Supernova Remnant. The 24mu and 70mu images show the morphology of the emitting region and allow comparison with the optical and X-ray emission. The IRS spectra, obtained at four independent locations show the variation of line emission and thermal dust emission in the region.

Anton I. Vasyunin (Max-Planck-Institute for Astronomy / The Ohio State University)
Impact of Grain Evolution on the Chemical Structure of Protoplanetary Disks
We study the impact of dust evolution in a protoplanetary disk around a T~Tauri star on the disk chemical composition. For the first time we utilize a comprehensive model of dust evolution which includes growth, fragmentation and sedimentation. A chemical model that includes a comprehensive set of gas phase and grain surface chemical reactions is used to simulate the chemical structure of the disk. We find that grain evolution has a major effect on the chemical composition of disks. This comes from the reduction of the total grain surface area above the midplane due to grain growth, and even more importantly, from sedimentation. The net effect of grain growth is suppressed by the fragmentation process which maintains a population of small grains that dominate the total grain surface area. The decrease in grain surface area leads directly to a reduced dust opacity and a different UV field in the disk. The disk becomes more transparent for external UV radiation. This effect is more pronounced in the inner disk, because grain growth is more efficient there. In general, the “three-layer” pattern in the chemical structure is preserved, but is shifted closer to the midplane. Such a disk has a smaller vertical extent compared to a disk without grain evolution. The column densities of most of the gas-phase species are enhanced by 1--3 orders of magnitude relative to those in a model with pristine dust. We show that column densities of certain species, like C2H, H2CO, HC(2n+1)N (n=0-3), H2O and some other molecules, as well as the C2H2/HCN abundance ratio which are accessible with Herschel and ALMA, can be used as observational tracers of early stages of the grain evolution process in protoplanetary disks.

Sven Van Loo (University Of Florida)
collaborators: Prof. Paola Caselli, Prof. Jonathan Tan, Prof. Tom Hartquist
C-type Shocks in Star-forming Regions
Jets and winds associated with low and high mass protostellar objects drive shocks into the dusty, molecular regions surrounding them. As the ionization fraction in these dark clouds is low, the gas and the interstellar magnetic field are weakly coupled. This coupling is mediated via ion-neutral and grain-neutral collisions, as the magnetic field forces the charged particles to move through the bulk of neutral particles. Sometimes this causes a shock to become continuous in all fluids. Such a shock is referred to as a C-type shock. Observational studies of the velocity widths of SiO emission suggest that most

shocks near low mass protostellar objects are C-type. Furthermore, SiO observations indicate that the protostellar winds and jets interact with clumpy structures along their propagation axis. We present time-dependent multifluid simulations following the evolution of C-type shocks interacting with regions of inhomogeneous density. These simulations include a self-consistent calculation of the thermal and ionization balance and a fluid treatment of grain dynamics. Our results show that the interaction produces a range of different waves and shocks and that it is likely that no steady C-type shocks exist in highly perturbed molecular regions. We will also show preliminary results of simulations including grain mantle and core sputtering to describe the release of SiO from grains to the gas phase. This allows us to understand how the SiO emission varies in time and space. Such information is necessary to interpret spectra of protostellar shocks obtained within Herschel guaranteed programs such as CHESS and WISH.

Yuan Yuan and David A. Neufeld (Johns Hopkins University)
Spitzer Observations of Supernova Remnants and Protostellar Outflows: Study of Physical Conditions and H2 Ortho-to-para Ratio
Interstellar shocks generated by supernova explosions and protostellar outflows have profound effects on the surrounding molecular cloud. The non-dissociative shocks heats the gas to several hundred or several thousand Kelvin and excites molecules to a series of high-lying energy levels. Many spectral lines have been detected toward those shocked molecular regions, especially in the infrared; among them, the H2 emission lines are the most important diagnostic for studying the physical conditions.

Thermodynamics and Mechanics of the Interstellar Medium

Mary Barsony (Space Science Institute)
IRS Spectral Mapping of the Nearby VeLLO Powering the Wasp-Waist Nebula
The outflow driven by the VeLLO, IRAS 16253-2429, is associated with bipolar cavities visible in scattered light in IRAC images--we refer to this object as the Wasp-Waist Nebula. IRS spectral maps of a ~1' x 2' area centered on the VeLLO were carried out. The outflow is imaged in all six H_2 transitions that fall within the SL spectral range, and displays a distinct S-shaped structure. Analysis of the H_2 spectra shows the outflow gas to be passing through Jump (J-type) shocks, with pre-shock densities $10^4 < n_H < 10^5$ /cm^3 in the red-shifted lobe and $n_H < 10^3$ in the blue-shifted lobe. Shock velocities of 5 km/sec < v_s < 10 km/sec are inferred for the red-shifted gas, and v_s=10 km/sec for the blue-shifted gas. The analysis of the H_2 lines demonstrates a new method for inferring magnetic field strengths in such dense, cold environments. Comparison of the data with the shock models of Wilgenbus et al. (2000) allows derivation of the transverse (to the shock) magnetic field strengths: 10-32 microGauss are found for the red-shifted lobe, and just ~3 microGauss for the blue-shifted lobe. We report the discovery of 11.3 micron PAH absorption permeating the dense envelope of this low-mass Class 0 object.

Joerg Fischera (ANU/Mount Stromlo Observatory)
Dust Attenuation Caused by Turbulent Media
Our ability to correct for dust attenuation caused by the dusty turbulent interstellar medium which is particularly strong in the ultraviolet and optical limits our understanding of basic astrophysical processes as the star formation rate in galaxies and consequently the star formation history in the universe. I will discuss how a distant turbulent screen affects the apparent dust attenuation and show how this attenuation is related to the statistical properties of the screen, the standard deviation and the power spectrum of the density fluctuations. In general a turbulent screen produces because of the in-homogeneous nature of a turbulent medium a flattening of the dust attenuation law characterized by a larger value of the absolute-to-relative extinction RV. For given statistical properties and dust content the attenuation flattens as function of thickness of the screen. In the limit of a thick screen which is thicker than the maximum cloud size the attenuation curve reaches an asymptotic behavior. This attenuation of maximum flatness is for given power spectrum of the density fluctuations determined by the product of the mean extinction at maximum length scale and the variance of the local density. As I will show the turbulent motion is a natural explanation of the flatter curvature of the attenuation curve derived for local star-burst galaxies, the so-called 'Calzetti extinction curve'.

Andy Green (Swinburne University)
Mechanics of Turbulent Star Formation
Kinematic studies of the ISM in high redshift galaxies find much higher velocity dispersions than in the local Universe, even for disk like systems. In parallel, deep imaging morphologies of early galaxies show massive star forming clumps, possibly embedded in disks. The contrast of these findings to the kinematics and morphologies of modern galaxies motivates simulations of turbulent clump clusters coalescing to form

bulge dominated disks between z~1 and z~0.1. I present kinematic evidence that turbulence is closely related to star formation. Furthermore, I confirm that clumpy galaxies at z~1 are embedded in faint disks, while similar clumpy galaxies still exist at z~0.1.

Pierre A. Guillard (SSC, IPAC, Caltech)
How do Radio-jet Driven Outflows Impact the Molecular Gas in AGN?
Though observations of ionized and neutral gas outflows in radio-galaxies (RG) suggest that AGN feedback has a galaxy-scale impact on the host ISM, it is still unclear how AGN feedback impacts the molecular gas, and if it can regulate star formation. We present Spitzer IRS and near-IR TripleSpec spectroscopy of RG with fast HI outflows. Remarkably, very bright, shock-excited line emission from warm H2 is detected in all of them. We discuss the kinematics and excitation of the molecular gas, as well as a model for H2 formation and excitation in a shocked multiphase ISM. This synergy between observations and modeling is a key to understand if radio-jet driven feedback can efficiently suppress star formation in massive early-type galaxies.

Christian D. Howard (SOFIA Science Center/USRA)
Herschel Observations of Taurus/ Auriga: [OI]63 Line and 63 um Continuum Emission
GASPS is a large Herschel Open time Key project that studies the evolution of gas in protoplanetary disks. We target about 240 nearby objects in Taurus and young associations covering stellar ages between 0.3 - 30 Myr. We use PACS aboard Herschel to observe continuum and selected gas tracers, like [OI] at 63 and 145 um, [CII] at 158 as well as several molecular lines like OH, H2O and CO. The strongest line we see is [OI] at 63 um. However, although it is clear that [OI] traces gas in the disk, it is also strong in jets and outflows. Using the sources observed so far (22 sources detected in both line and continuum of 43 sources observed at 63 um) in Taurus/Auriga we explore how the [OI] line strength correlated with 63 um continuum, disk mass, accretion rate, stellar luminosity, and strength of the [OI] 6300 angstrom emission for both outflow and non-outflow sources. We find a clear correlation between the strength of the [OI] 63 um emission and 63 um continuum for both outflow and non-outflow sources, but a clear separation between the two. In outflow sources the line is about 4 times stronger than in non-outflow sources

Ute Lisenfeld (Universidad de Granada/IPAC)
Shock Acceleration of Relativistic Particles in Galaxy-galaxy Collisions
Collisional galaxy systems, like the so-called Taffy galaxies, UGC 12194/5, and UGC 813/6, are systems where two spiral galaxies collide face-on. In the collision the diffuse parts of the two interstellar media interact supersonically and produce a bridge of shocked atomic and molecular gas and of radio continuum emission between them. The radio continuum emission of the bridge constitutes almost half of the total emission of the system and has the consequence that the system is radio loud by a factor of about two with respect to the FIR-radio correlation. We propose that the radio continuum emission in the bridge is produced by diffusive shock acceleration in the shocks that compress and mutually decelerate the respective interstellar media. We present a model for the

acceleration of relativistic particles in these shocks and calculate the resulting radio emission and its spectral index and show that the predictions are in agreement with the observations. In this picture the excess radio emission from collisional bridges is the result of an additional form of Cosmic Ray acceleration that is NOT related to star formation. The process rather reinforces the standard picture for individual galaxies in which the correlation between the FIR and the radio continuum emission is due to their star formation activity. The process discussed here is likely to take place in other systems as well, as in galaxy clusters, groups of galaxies and, rather generally, in high-redshift systems.

Toshiya Ueta (Univ. of Denver)
Interactions Between the ISM and Stellar Winds from AGB Stars: Spitzer Discovery and AKARI & Herschel Follow-up
Observations made by Spitzer discovered that benign dusty outflows from asymptotic giant branch (AGB) stars can induce shocks at the interface between the stellar wind and interstellar medium (ISM). A recent AKARI imaging survey of the circumstellar envelopes of AGB stars have detected faint far-IR structures suggesting AGB wind-ISM shock interactions in many objects, while observations made in other wavelengths (especially in UV by GALEX and in 21 cm atomic H line by VLA) have provided supporting insights. Most recent Herschel observations provide detailed views of these interface regions at the unprecedented spatial resolution. Therefore, the AGB wind-ISM interface regions would permit us to glimpse how the AGB ejecta eventually merge with the ISM with or without shock interactions, which have obvious implications to the enrichment of the Galaxy by these AGB stars. In this contributed review, I will summarize the development of research on interactions between the AGB winds and ISM which is made possible by observations made with Spitzer, AKARI, and Herschel.

Andrea Urban (JPL/Caltech)
The Ubiquity of Lognormal Column Density Distributions
We investigate the origin of the observed lognormal column density distribution seen in molecular clouds. Because simulations of supersonic turbulence reproduce this feature, it is often perceived as an indication that supersonic turbulence dominates the dynamics of the observed clouds. We study, using two different simulations, neither of which is dominated by supersonic turbulence, and an analytic model, whether lognormal column density distributions are due solely to supersonic turbulence. We investigate (1) a simulation of a molecular cloud core dominated by self-gravity and radiation feedback from the forming protostars, (2) a simulation of a magnetically supported molecular cloud with subsonic motions and ambipolar diffusion, and (3) an analytic Bonnor-Ebert-type sphere with self-gravity, opposed by thermal pressure only. We find, in all three of these extremely different test cases, lognormal column density distributions. Therefore we can conclude that lognormal column density distributions are not unique to simulations of supersonically turbulent molecular clouds. They are rather a general feature of cloud models. In summary, we find that an observed lognormal column density distribution cannot be used as evidence of supersonic turbulence dominating the dynamics of molecular clouds.

Coupling of Radiation, Gas and Dust

Eduardo de la Fuente Acosta (Universidad de Guadalajara)
Ultracompact HII Regions with Extended Emission seen by Spitzer
Here we present the results of a morphological study performed to a sample of Ultracompact (UC) HII regions with Extended Emission (EE) using Spitzer-IRAC+MIPS imagery and VLA radio-continuum maps. A comparison between maps and images is presented. Our goal is to find the relation between the ultracompact and extended emissions. Also a Spitzer-IRAC photometry of a sub-sample of 13 UC H II regions with EE based on GLIMPSE legacy data were performed.

In all cases, we found an IRAC counterpart to the UC source within ~3 arcsec tolerance, as well as embedded stars and YSOs inside of some of the EE areas. These stellar sources might contribute as an important source of ionization to the EE, and can be part of a more numerous young stellar cluster from which the UC is one of the members. Preliminary results of this study are presented in de la Fuente et al., 2009, Revista Mexicana de Astronomia y Astrofisica (Serie de Conferencias), 37, 13.

B-G Andersson (SOFIA Science Center/USRA)
Observational Testing of Radiative Alignment Torque Theory
One of the longest standing conundrums of interstellar astronomy is: what aligns the dust grains, causing interstellar polarization? Despite over 60 years of observational and theoretical work a conclusive answer is still missing. Modern "Radiative Alignment Torque" (R.A.T.) theory favors a direct alignment driving by the radiation field originating in the differential coupling of the inherent grain helicity to the right and left-hand circular polarization components of the radiation field. This theory - for the first time - provides quantitative, testable, predictions of grain alignment in different environments. We will discuss a set of specific observational tests of R.A.T. theory using optical/NIR as well as FIR/sub-mm wave data: 1) The grain alignment is a smoothly deceasing function of optical depth 2) Grain alignment is active at great optical depth, near embedded sources and respond to variations in the dust temperature. 3) For star-less cores an opacity is eventually be reached where no gains are large enough to couple to the remaining radiation field 4) The relative angle between the magnetic field and the radiation anisotropy directions influence the alignment efficiency and 5) While grain alignment does not drop of precipitously at opacities where H2 dissociation ends, H2 formation does play a secondary role in grain alignment and its influence constrain the fraction of super-paramagnetic grains. This combination of quantitative theoretical predictions and specific observational tests promises to provide not only a solution to the long standing issue of interstellar grain alignment but will as a consequence allow a better understanding of the Galactic magnetic field as well as several aspects of the micro-physics of the dust.

Pedro Beirao (Spitzer Science Center - Caltech)
Mapping the Properties of the ISM in the Seyfert Galaxy NGC 1097 with Herschel-PACS and Spitzer-IRS

NGC 1097 is a nearby SBb galaxy with a Seyfert nucleus and a bright starburst ring. It has also a large-scale bar feeding gas into the central ring. We study the physical properties of the interstellar medium (ISM) in the ring and along the bar of NGC 1097 using spatially resolved mid-infrared and far-infrared spectral maps obtained with the Herschel-PACS and Spitzer-IRS spectrometers. In particular, we map the important ISM heating and cooling tracers such as PAH emission bands, infrared fine structure lines, and warm molecular hydrogen emission lines. We observe that in the [OI] 63 μm, [OIII] 88 μm, and [NII] 122 μm line maps, the emission is enhanced in clumps along the NE part of the ring. The [OI] 63 μm/[CII] 158 μm ratio varies smoothly throughout the central region, and is enhanced on the northeastern part of the ring, which may indicate a stronger radiation field. The PAH emission distribution in the ring coincide with the [OI]/[CII] distribution, indicating that the PAH flux correlates with the intensity of the radiation field. The ratio of the H2 lines S(3)/S(2) is higher at the nucleus, indicating possible gas heating by the AGN, and in regions where the dust lanes encounter the ring, possibly indicating shocks caused by gas compression.

Laurent Cambresy (Observatoire de Strasbourg)
Variation of the Extinction Law in the Trifid Nebula

We look for variations of the extinction law within the Trifid nebula region using the 2MASS, UKIDSS and Spitzer/GLIMPSE surveys. The technique is to inter-calibrate color-excess maps from different wavelengths to derive the extinction law and to map the extinction in the Trifid region. We measured the extinction law at 3.6, 4.5, and 5.8 microns and we found a transition at Av~20 mag. Using these results the color-excess maps are converted into a composite extinction map of the Trifid cloud at a spatial resolution of 1'. A tridimensional analysis along the line-of-sight allowed us to estimate a distance of 2.9 kpc for the Trifid. The comparison of the extinction with the 1.25mm emission shows the millimeter emissivity is enhanced in the dense condensations of the cloud. Our results suggest a dust transition at large extinction which has not been reported so far and dust emissivity variations in the Trifid molecular cloud.

Simon P. Casassus (Universidad de Chile)
Cm-wave Continuum Radiation from PDRs: the Radio/H2 Correlation

Bright cm-wavelength (31GHz) radio continuum has been observed from canonical dark clouds. What is the nature of the cm-wave emitters? Do the cirrus clouds that originate the `anomalous CMB foreground' radiate by the same emission mechanisms as the dark clouds? Our study of rho Oph provides the following hints. Although the cm-waves are correlated with mid-infrared dust on ~1deg scales in the diffuse ISM, this correlation breaks down on 10arcmin scales in rho Oph. CBI2 observations confirm that spinning dust emissivities per nucleon would have to vary by two-orders of magnitudes within rho Oph. However, an ATCA+CABB mosaic of rho Oph reveals spectral variations in the cm-wave continuum. At 30arcsec resolutions, the 17GHz and 20GHz intensities in the rho Oph W filament follow surprisingly well the IRAC 8um image, despite the breakdown of the radio/IR correlation on 10arcmin scales. The 33-39GHz filament is also parallel to IRAC~8um, but offset by 15-20arcsec towards the UV source. Comparison with H2 imaging and spectroscopy reveals a radio-H2 correlation, and formation-pumped spectroscopic signatures. Overall, the rho Oph data may tentatively be interpreted in the context of a contribution to grain spin up from H2 formation.

Kevin V. Croxall (University of Toledo)
The Physical Conditions In The ISM: Observations Of NGC 4559 With The Herschel/PACS Spectrometer
The cooling of the neutral interstellar medium in galaxies is dominated by far-infrared line emission. This emission is characterized by features which reveal the physical conditions of the phases of the ISM as well as indicate the source of the heating. Despite many efforts, studies of heating and cooling via infrared line emission were hampered by a lack of spatial resolution. However, the recently launched Herschel and Spitzer space telescopes enable us to spatially map emission from mid- and far-infrared lines in nearby galaxies rather than adopting global values. We highlight early results from the KINGFISH spectroscopic program which is mapping strong cooling lines in several nearby galaxies using the Herschel Space Observatory. These observations are complemented by Spitzer/SINGS 5-35µm data to permit a full census of line and dust emission. In particular we focus on emission from resolved regions of NGC 4559, a nearby late type spiral galaxy that was part of the KINGFISH science demonstration program. Line diagnostics of most regions of emission are consistent with predictions PDR models. Nevertheless, we have detected an excess of [C II] 157 µm emission from the diffuse portions of NGC 4559's disk. Based on observations obtained with the Herschel Space Telescope as part of KINGFISH (Key Insights on Nearby Galaxies: a Far Infrared Survey with Herschel; P.I.: R.C. Kennicutt), one of the Herschel Open Time Key Projects.

Mathieu Compiegne (SSC/IPAC/Caltech)
Dust in the Diffuse Emission of the Galactic Plane – the Herschel/Spitzer SED Fitting
We will present our first results obtained while analyzing the Herschel/Spitzer data toward the Hi-Gal SDP field at l=59 deg using the DustEM model. DustEM is a physical dust model that is available online (Compiegne et al., 2010). We use this model to perform a pixel by pixel fitting of the full dust SED (8-350 microns), adjusting four of the model parameters: (i) PAHs and (ii) very small grains abundances, (iii) a scaling factor of the exciting radiation field and (iv) the column density. As we will show, this method allows us for a better separation of the emission components that contribute to the different photometric bands and then, to better understand the spatial structure of the emission at the corresponding wavelengths. It also points out the great potential of the Herschel/Spitzer data synergy analyzed with a physical dust model for the study of dust evolution.

Rafik Ladj (University of Sciences and Technology Houari Boumediene)
The Role of Nuclear Activity as the Power Source of Ultraluminous Infrared Galaxies

We present the results of a 5-8 micron spectral analysis performed on the largest sample of local ultraluminous infrared galaxies (ULIRGs) selected so far, consisting of 164 objects up to a redshift of ~0.35. The unprecedented sensitivity of the Infrared Spectrograph onboard Spitzer allowed us to develop an effective diagnostic method to disentangle the active galactic nucleus (AGN) and starburst (SB) contribution to this class of objects. The intrinsic bolometric corrections are estimated for both the components, in order to obtain the relative AGN/SB contribution to the total luminosity of each source. Our main results are the following: 1) The AGN detection rate among local ULIRGs amounts up to 70 per cent, with 113/164 convincing detections within our sample, while the global AGN/SB power balance is ~1/3. 2) A general agreement is found with optical classification; however, among the objects with no spectral signatures of nuclear activity, our IR diagnostics find a subclass of elusive, highly obscured AGN. 3) We analyze the correlation between nuclear activity and IR luminosity, recovering the well-known trend of growing AGN significance as a function of the overall energy output of the system: the average AGN contribution rises from ~10 to ~60 per cent across the ULIRG luminosity range. 4) We confirm that the AGN content is larger in compact systems, but the link between activity and evolutionary stage is rather loose. 5) By analyzing a control sample of IR-luminous galaxies around z ~ 1, we find evidence for only minor changes with redshift of the large-scale spectral properties of the AGN and SB components. This underlines the potential of our method as a straightforward and quantitative AGN/SB diagnostic tool for ULIRG-like systems at high redshift as well.

Julia C. Lee (Harvard University)
Determining the Quantity and Composition of Dust using X-rays from Black Holes and Neutron Stars

High spectral resolution X-ray instruments on powerful X-ray satellites (e.g. Chandra, XMM-Newton) pointed through dust and gas at bright black holes and neutron stars can be used to study dust and intervening material in unique ways. With the new subfield of Condensed Matter Astrophysics as its goal, I will discuss my group's efforts to combine techniques and knowledge from physics disciplines (astrophysics, atomic physics, and experimental condensed matter/solid state physics), geology, and chemistry, to determine the quantity and composition of interstellar gas and dust in the ISM and ionized environments, in a way that has not been fully embraced before. Through a combined experimental program at synchrotron beam-lines and space-based X-ray (Chandra and XMM) observations of compact objects, we present initial results based on X-ray absorption studies, and compare with Spitzer IRS studies along the same lines-of-sight to show that these two wavebands are sensitive to different populations of grains. Efforts to provide a database of absolutely calibrated X-ray standards (including stardust samples), and progress, will also be discussed.

Nanyao Lu (NHSC/IPAC/Caltech)
A Herschel SPIRE Study of M81: Separating Cold and Warm PAH Emissions
We study correlations among three distinct dust emission components in the interstellar medium of the galaxy M81 at a sub-kpc resolution: (a) I_8, the surface brightness of non-stellar emission in Spitzer IRAC 8 um band, dominated by the so-called PAH emission features, (b) I_24, that of hot continuum emission in Spitzer MIPS 24 um band, arising from small dust grains powered mainly by young stars, and (c) I_500, that of cold dust continuum emission in Herschel SPIRE 500 um band, from large dust grains heated by evolved stars. Both I_8/I_500 and I_24/I_500 ratios increase towards active star-forming regions, consistent with the view that both (a) and (b) are correlated with current star formation. But as I_24/I_500 decreases to zero, I_8/I_500 approaches to a finite, positive value of 0.058 (+/- 0.001). This implies that 62% (+/- 6%) of the 8 um non-stellar emission is "cold," arising from regions, where the 24 um emission is relatively insignificant. Since it is likely that the fraction of this cold component in the PAH emission varies from galaxy to galaxy, making the PAH luminosity a rather poor star formation tracer in general.

Massimo Marengo (Iowa State University)
An Infrared Nebula Associated with Delta Cephei: Evidence of Mass Loss?
We present the discovery of an infrared nebula around the Cepheid prototype delta Cephei and its hot companion HD 213307. Large scale (~ 2.1 x 10^4 AU) nebulosity is detected at 5.8, 8.0, 24 and 70 micron. Surrounding the two stars, the 5.8 and 8.0 micron emission is largely attributable to Polycyclic Aromatic Hydrocarbon (PAH) emission swept from the ISM by a wind originating from delta Cephei and/or its companion. Stochastically heated small dust grains are the most likely source of the 24 and 70 micron extended emission. The 70 micron emission, in particular, resembles a bow shock aligned in the direction of the proper motion of delta Cephei. This discovery supports the hypothesis that delta Cephei may be currently losing mass, at a rate in the range ~ 5 x 10^-9 to 6 x 10^-8 Mo/yr, which can explain at least in part the still unresolved Cepheid mass discrepancy.

Mark R. Morris (UCLA)
Warm Molecular Hydrogen in Diffuse Clouds above the Galactic Center
Warm molecular hydrogen has been observed toward 17 positions in relatively high-latitude diffuse clouds with the InfraRed Spectrometer on the Spitzer Space Telescope. Located at distances of 60 to 120 pc above the Galactic plane, these quasi-continuously distributed clouds are far above the gas layer of the dense, central molecular zone. The S(0) through S(4) lines are all observed, with an intensity that is proportional to the continuum intensity at 24 µm. The characteristics of the H2 emission will be compared to those obtained for the SINGS galaxy sample. These results help inform the question of how much of the global molecular hydrogen emission from galaxies emanates from diffuse clouds, rather than PDRs associated with dense molecular clouds.

Eric J. Murphy (Caltech/SSC)
Extragalactic Anomalous Dust: A First Detection
We report on the radio to infrared continuum emission properties for an outer-disk star-forming region in the nearby galaxy NGC~6946. This region has been found to exhibit tentative evidence for anomalous dust emission (Murphy et al. 2010), and would therefore be the first such extragalactic detection. Using new CARMA imaging at 90~GHz, we believe to have confirmed this claim. We find that models explaining this feature as the result of dipole emission from rapidly rotating ultrasmall grains are able to reproduce the observations for reasonable interstellar medium conditions. We also find that the peak of the 90~GHz emission to be slightly offset from the individual H{\sc ii} regions making up this star-forming complex as identified through Hα, 8, and 24~μm imaging, consistent for such an emission component. While these results suggest that the use of Ka-band data as a measure of star formation activity in external galaxies may be complicated by the presence of anomalous dust, it is unclear how significant a factor this will be for globally integrated measurements as the excess emission accounts for <10% of the total Ka-band flux density from a total of 10 regions studied.

Ji Yeon Seok (Seoul National University)
PAH Emission from Supernova Remnants in the Large Magellanic Cloud
We present infrared studies of the supernova remnants (SNRs) in the Large Magellanic Cloud (LMC) using the infrared space telescope AKARI. Eight out of 21 SNRs in the AKARI LMC survey area (12 square-degree) are detected in near and/or mid-infrared bands. We have performed near-infrared (2.5-5 micron) spectroscopic follow-up observations toward infrared bright SNRs. We detect 3.3 micron polycyclic aromatic hydrocarbon (PAH) features in two SNRs, N49 and N63A, which is for the first time to report the presence of the 3.3 micron PAH features associated to a SNR. In N49, we compare the distribution of the PAH emission to those of Br_alpha (4.05 micron) and H2 1-0 O(3) (2.80 micron) lines. The morphology of the PAH emission shows both similarity and dissimilarity to those of H2 and Br_alpha emission. We also investigate archival Spitzer IRS data of N49 and find signatures of other PAH band emissions at 6.2, 7.7, and 11.3 microns. The band ratios indicate that the PAHs are mainly neutral. We discuss the physical conditions in the shocked environment and discuss the origin of the PAH emission.

Marcella Veneziani (SSC - Caltech)
Variation of the Spectral Index of Dust Emissivity from Hi-Gal Observations of the Galactic Plane
Variations in the dust emissivity are critical for gas mass determinations derived from far-infrared observations, but also for separating dust foreground emission from the Cosmic Microwave Background (CMB). Hi-GAL observations allow us for the first time to study the dust emissivity variations in the inner regions of the Galactic plane at resolution below 1deg. We present maps of the emissivity spectral index derived from the combined Herschel PACS 160 μm, SPIRE 250 μm, 350 μm, and 500 μm data, and the IRIS 100 μm data, and we analyze the spatial variations of the spectral index as a function of dust temperature and wavelength in the two Science Demonstration Phase Hi-GAL fields, centered at l=30° and l=59°. Applying two different methods, we determine

both dust temperature and emissivity spectral index between 100 and 500 μm, at an angular resolution (Θ) of 4'. Combining both fields, the results show variations of the emissivity spectral index in the range 1.8-2.6 for temperatures between 14 and 23 K. The median values of the spectral index are similar in both fields, i.e. 2.3 in the range 100-500 μm, while the median dust temperatures are equal to 19.1 K and 16.0 K in the l=30° and l=59°field, respectively. Statistically, we do not see in the spectra any significant deviations from a power law emissivity between 100 and 500 μm. We confirm the existence of an inverse correlation between the emissivity spectral index and dust temperature, found in previous analyses.

David G. Whelan (University of Virginia)
Modeling Natal Super Star Cluster SEDs in the Post-Spitzer Era
The level of sophistication available in radiative transfer codes has ballooned in the last decade, making the use of good PAH templates, complex geometries, and turbulent media common. I will describe my work to model natal super star clusters (Whelan et al. submitted) with a modern three-dimensional code (seminal paper by Whitney et al. 2003; more recently, Wood et al. 2008). I have computed simple models with different star formation efficiencies, envelope radii, and clumpy dust distributions to compare to data from Spitzer and Herschel and, one day soon, JWST. JWST in particular should have high enough spatial resolution to resolve natal super star clusters in their dense star formation environments. A comparison of these models to infrared point sources in the Antennae will be made to underline the importance of both higher spatial resolution and the use of complex geometries in studying these objects; the simple geometry employed in my current work, while a necessary first step, is easily shown to not be enough to account for all of an observed spectrum's features. Various features of more complex geometries will be investigated.

Brian J. Williams (North Carolina State University)
Collisional Heating of Porous Grains in Fast Non-Radiative Shocks
Emission from interstellar dust grains is typically modeled assuming that grains are homogeneous solid particles. Recent work has shown that this may not be the case in the ISM, and that grains may be composed of more than one type of material and/or contain some fraction of their volume occupied by vacuum. Porous grains absorb and re-radiate energy differently than solid grains, and virtually all previous studies of porous grains have focused on radiative heating and absorption properties in the optical/UV. Here, we examine the effects of collisional heating of porous grains, in the context of the hot post-shock region behind supernova remnant (SNR) shocks. Modeling IR emission from warm grains, particularly when combined with X-ray spectroscopy of the hot plasma, is a powerful diagnostic of SNR conditions, such as gas density, ambient dust-to-gas mass ratio, and total dust mass present, but these numbers all have significant dependence on grain properties. For a grain porosity of 50%, the density required is a factor of 3 higher than that needed for solid grains. However, porous grains are more efficient radiators per unit mass, and less mass is required to produce observed IR luminosities. Degeneracies in model spectra are present over the limited wavelength range of Spitzer, but additional long-wavelength observations with Herschel could significantly constrain models further. Sputtering rates for porous grains are different as well, and we show implications for

liberation of refractory elements into the gaseous phase behind a range of shock speeds and conditions. Collisional heating studies in the IR complement radiative optical and UV studies, and provide new constraints on dust physics in the ISM. I will discuss applications of both porous and compact grain models to the young SNRs 0509-67.5 and 0519-69.0.

Properties over Galactic and Cosmic Timescales

Lori E. Allen (NOAO)
The Herschel Orion Protostar Survey
The Orion molecular cloud complex is the most active region of star formation within 500 pc of the Sun, with over 400 protostars identified by Spitzer in a diverse range of environments. We are now collecting extensive observations on 280 Orion protostars, including 5-40 um Spitzer spectroscopy, near-IR imaging and spectroscopy with Hubble and ground-based telescopes, and a Herschel open time key project of PACS far-IR imaging and spectroscopy. With these data we can determine the fundamental properties (multiplicity, gas infall rate, bolometric luminosity, outflow cavity geometry) of a large sample of protostars in a single cloud complex. We are additionally obtaining data on the temperature, turbulence and column density of the surrounding molecular gas from a number of ground-based telescopes. This program will provide new insights into protostellar evolution and how protostars are influenced by their surrounding environment (molecular gas properties, density of stars, radiation fields). We will discuss initial results including the Spitzer IRS detection of crystalline material in a cold protostellar envelope around a protostar in the OMC2 region of Orion, the SED modeling of a group of protostars associated with the Herbig-Haro complex HH1-2 showing both rapidly accreting objects as well as objects that have essentially completed their accretion, and the 58-190 um PACS spectrum of the protostar powering HH1/2 exhibiting numerous lines of water, OH and CO.

Benjamin J. Bertincourt (Columbia University)
S5: The Spitzer SDSS Statistical Spectroscopic Survey
The SDSS optical spectroscopic database has vastly enhanced our knowledge of galaxy evolution and star-formation processes across galaxy types. As the most unbiased sample it allows for very accurate determination of observable quantities such as stellar mass, Star-Formation Rates (SFRs), Star-Formation Histories (SFHs) - when combined with models of galaxy stellar populations - across a large range of physical properties. The S5 project extends this very successful optical sample into the mid-infrared using the capabilities of the Spitzer/IRS instrument. Using high (SH) and low (SL+LL) resolution spectroscopy we probe dust emission over a broad range of grain sizes and temperatures. In addition, the detection and analysis of the Polycyclic Aromatic Hydrocarbons (PAHs) gives strong insights on the dust composition of the ISM and allow the identification of the main source powering the IR output: star-formation or AGN mechanisms. High resolution spectroscopy gives access to accurate measurements of fine structure line fluxes efficiently probing the excitation conditions in the ISM of those galaxies. I will present results obtained from the S5 sample and discuss its importance in the light of previous extensive spectroscopic surveys such as SINGs.

Nicolas Billot (NHSC - Caltech)
On the Distribution of Far-IR Sources in the HiGAL SDP Fields
The Hi-GAL Open Time Key Program is a survey of the inner Galactic Plane covering over 270 square degrees in 5 wavelength bands (Molinari et al., 2010). Thousands of compact sources were extracted from the 2 Science Demonstration Phase Fields centered

at l=59 and l=30. We characterize the spatial distribution of these sources using the Minimum Spanning Tree (MST) method. We investigate the correlation between source clustering properties with their intrinsic physical properties - such as mass, luminosity, or evolutionary stage (Elia et al., 2010) - and also with their immediate environment (UC HII regions, IRDCs, diffuse ISM). Preliminary results from our MST analysis has revealed two different populations of objects in the SDP fields: one population of FIR-bright sources (presumably protostars) appears to be grouped in compact clusters around HII regions while the other population of submm-bright objects (cold cores) seems to be distributed in wider and looser groups. Such a difference in spatial distribution could be attributed to events of triggered star formation.

Harold M. Butner (James Madison University)
DEBRIS - A Update on the Search for Kuiper Belts Around the Nearest Stars
DEBRIS (Disk Emission via a Bias-free Reconnaissance in the Infrared/Submillimetre) is an open time key project on Herschel. It aims to conduct an unbiased statistical survey for debris disks around a range of spectral types from A0 through M7. The survey list consists of 446 primaries, 348 of which are to be observed by the DEBRIS team and 98 by the DUNES (DUst around NEarby Stars) team. We will discuss some of our early results. We will highlight how the survey will have its biggest impact: establishing the true incidence of debris disks across spectral classes from A to M and characterizing the debris disk population's properties as a function of central star's spectral type.

Michelle E. Cluver (SSC/Caltech)
Death by Debris: Constructing a New View of Star-formation Quenching in Compact Groups
Several recent studies show that Compact Groups appear to follow an evolutionary sequence, linked to gas depletion, caused by interactions in the dense environment. Spitzer photometry of Hickson Compact Groups (HCGs) show a distinctive gap in IRAC colour-colour space, suggesting accelerated evolution from dusty to dust-free systems and which appears to correlate with galaxies transitioning from gas-rich to gas-poor. However, the mechanism responsible is poorly understood. Ram-pressure stripping with a hot, tenuous medium, by analogy with clusters, was thought to dominate, but the HI-depletion in the member galaxies appears uncorrelated with the presence of hot X-ray gas. Based on our recent Spitzer IRS spectroscopy of a sample of 23 HCGs, we propose a new hypothesis that connects the colour evolution to the HI-stripping seen in the group galaxies. Our results show several systems with enhanced warm molecular hydrogen emission, residing in the IRAC colour-colour gap. This could be the result of shock excitation not unlike what is seen in Stephan's Quintet, an HCG containing the dramatic collision of an intruder galaxy with a stripped HI filament, producing a group-wide shock. Our proposed scenario has galaxies colliding with previously removed tidal debris (forming a "sea" of material), that either heats the disk ISM or removes it through "viscous stripping" (i.e. inhomogeneous ram-pressure stripping), thus shutting off star formation and accelerating the transition from dusty, gas-rich disks to gas-poor, dust-free systems. These new results will be discussed, as well as how Herschel can help test this new picture of dynamical interactions within Compact Groups.

Alison F. Crocker (University of Massachusetts, Amherst)
The Diffuse Fraction of PAH Emission in Spiral Galaxies
Emission from polycyclic aromatic hydrocarbons (PAHs) is used as a star formation rate tracer at both low and high-redshifts. However, PAHs can be excited not only by hot young stars, but also by the softer radiation from older stars. Yet no study quantifying this 'diffuse' PAH component has yet been performed. To do this, we compare the Spitzer 8 μm emission (stellar subtracted) to the distribution of the Hα recombination line in a sample of SINGS spiral galaxies. Dust-corrected Hα emission accurately traces star formation as only hot young stars can produce the required ionizing continuum (outside of the immediate environs of an AGN or strong shocks). The 8 μm and Hα images show qualitative differences, with the Hα appearing much more limited to clumpy HII regions and the 8 μm having a smoother appearance (after convolution to the same resolution). Considering the only diffuse regions (i.e. ignoring the identified HII regions), we see that the diffuse PAH emission is a significantly greater fraction (~30%) of the galaxies' total PAH emission than the Hα emission is (~10%) of the total Hα emission. This difference implies that, at minimum, about 20% of the PAH excitation in normal star-forming spiral galaxies is due to older stars. We additionally discuss the variations seen between the different galaxies and the radial dependence of the diffuse PAH emission.

Daniel A. Dale (U. Wyoming)
The Infrared-Ultraviolet Properties of Dwarf Galaxies
The infrared-to-ultraviolet ratio in galaxies has long been known to be correlated with their ultraviolet color. The tightness of this relation for the most vigorously star-forming galaxies provides a useful tool for estimating the internal extinction within both local starbursts and high redshift systems such as Lyman break galaxies. The advent of sensitive observations with GALEX and Spitzer has allowed study of the "IRX-beta" relation in lower luminosity targets, including even dwarf galaxies. Recent work has shown that normal galaxies exhibit far more scatter in IRX-beta than do starbursts, and intriguingly, dwarf galaxies show relatively red ultraviolet colors. I will review current efforts to understanding this relation, with a particular focus on low metallicity dwarf galaxies, since they can serve as local analogs to higher redshift systems. Finally, I will preview what improvements we can expect from the more comprehensive infrared coverage afforded by the Herschel Space Observatory.

Daniel A. Dale (U. Wyoming)
The Attenuation by Dust Within Galaxies at Intermediate Redshifts
We report results from the Wyoming Survey for H-alpha (WySH), a comprehensive survey to probe the evolution of star-forming galaxies over the latter half of the age of the universe (z~0.8 to the present).The H-alpha data from WySH are supplemented by archival infrared and ultraviolet data to provide a multi-wavelength look at the evolution of the attenuation by dust within galaxies. An epoch-to-epoch comparison at fixed star formation rate suggests a mild decrease in dust attenuation with redshift.

Jeremy Darling (University of Colorado)
Physical Molecular Probes of Star-Forming Galaxies
The quantum structure of simple molecules can provide astronomers with useful probes of physical conditions, such as thermometers, magnetometers, and densitometers. I will discuss new advances in employing non-thermal molecular absorption and emission as physical probes in star-forming galaxies including OH and water masers and the formaldehyde "dasar": (1) I will present a new understanding of the root causes of OH megamaser emission and describe what OH megamasers physically indicate in merger-induced starbursts, particularly in terms of gas density and dust properties. OH megamasers also provide an in-situ magnetometer via Zeeman splitting and offer the opportunity to measure magnetic fields at the peak of cosmic star formation. We suggest that these new insights can provide predictions for subsequent galaxy and black hole evolution and for the timing, duration, and physics of extreme starbursts. (2) Molecules can conversely be coaxed into non-thermal absorption, such as OH "conjugate" lines (useful for precision measurements of fundamental physical constants) and the formaldehyde (H2CO) "dasar," a distance-independent tracer of molecular gas density and star formation. I will discuss the use of the formaldehyde densitometer in star-forming galaxies as well as the idea of a formaldehyde "deep field" that would provide a distance-independent mass-limited probe of the cosmic history of star formation.

Gary J. Ferland (Univ of Kentucky)
Cold Gas and Dust in Cool-core Clusters of Galaxies
Many brightest-cluster galaxies in cool-core clusters are surrounded by networks of filaments, first detected from their optical emission. Recent observations have shown that the filaments have large reservoirs of molecular gas and that they are surrounded by a soft x-ray halo. Central questions include the energy source for the filament emission, the origin of the filaments, and how they relate to feedback processes within the cluster. I will describe our recent work, in MNRAS 392, 1475, and the extensions now underway to understand the chemistry and excitation of these remarkable environments.

Sebastian Haan (Spitzer Science Center/ Caltech)
IRS Spectral Mapping of Major Mergers along the Toomre Sequence
Interactions and mergers are important drivers of galaxy evolution and are likely responsible for the formation of the most luminous galaxies observed. We present Spitzer IRS spectral mapping observations of a sample of eight nearby, IR bright merging galaxies that span the range from early to mid to late major mergers. Our maps of the mid-IR features reveal the spatial variations of dust temperatures, masses, grain sizes, and the ionization state of the interstellar medium. Overall, we find that local variations of the IR properties are more significant than evolutionary trends along the Toomre Sequence.

Daniel J. Hanish (SSC)
SAFIRES: Spitzer Archival FIR Extragalactic Survey
The Spitzer Science Center's Source List project will enhance the Spitzer Heritage Archive (SHA) by uniformly processing mosaics and extracting individual sources in approximately 1500 square degrees, including approximately 30 million sources. The SSC Source List project will consist of the four Spitzer IRAC channels, between 3 and 8

microns, and the 24-micron MIPS channel. We are in the process of expanding this Source List to take advantage of the sensitivity of the MIPS 70um and 160um imaging modes, resulting in a well-calibrated set of FIR images across approximately 600 square degrees of the extragalactic sky. The resulting list of FIR sources will enable a variety of science projects, such as allowing us to better characterize the FIR luminosity functions and SED evolution of star-forming galaxies.

Tien-Hao Hsieh (National Tsing Hua University)
Populations of Young Stellar Objects in Nearby Molecular Clouds
We develop a new method to identify YSOs from star-forming regions using the photometry data of the Spitzer space telescope. Because SEDs of YSOs are similar to SEDs of background galaxies and Spitzer is sensitive enough to detect those galaxies, it has been difficult to separate YSOs and galaxies using only those photometry data. To solve this problem, previous works have developed several criteria according to the difference of the areas occupied by YSOs and galaxy sample in color-magnitude and color-color diagrams (hereafter CMD and CCD). However, different works used different CMDs and CCDs and defined criteria for separating YSOs and galaxies are often set by eyes. Here we develop a new method to measure the probability for a source to be a background galaxy; we calculate the density of pure galaxy sample in the multi-dimensional magnitude space and use the density as the probability of background galaxy. Our method is equivalent to use all CMDs and without artificial criteria. Thus, we can fairly identify the YSOs in the star-forming regions.

Hanae Inami (SSC/Caltech, JAXA)
The Off-nuclear Obscured Starburst Source in the Interacting Galaxy IIZw096, Observed with OSIRIS
The infrared luminous galaxy IIZw096 is an interacting galaxy known to host a compact off-nuclear buried source (Goldader et al. 1997). The Spitzer space telescope revealed that this source itself dominates ~80% of the far-infrared emission of the entire system and that it is powered by a starburst (Inami et al. 2010). We observed this source with the KeckOH-Suppressing Infra-Red Imaging Spectrograph (OSIRIS) with the adaptive optics system, using the Kcb filter which covers the wavelength range between 1.97 micron and 2.38 micron. In this poster, we will show spectra, line flux maps, and line velocity maps of this source. These results let us determine the scale of the starburst, stellar populations, and gas kinematics to understand the off-nuclear merger-induced source.

Di Li (Jet Propulsion Lab)
Probing A Key Step of ISM Evolution
The crucial step in star formation and ISM evolution is the transition from diffuse, largely atomic gas to dense, molecular clouds. Even 60 years after the first discovery interstellar gas (HI) and immense volume of knowledge on molecular clouds, the quantitative understanding of this transition phase is still sketchy. I will discuss recent progresses in measuring the content (HI, CI, and C+) and time scale of this transition phase. The results of these research will have impact on our understanding of galaxy evolution, especially on efforts of connecting cold dark matter simulation to observable matter.

Yiming Li (University of Massachusetts)

Spitzer 70 micron Emission as a SFR Indicator for Sub--Galactic Regions

We use Spitzer 24micron, 70micron and ground based Hα data for a sample of 40 SINGS galaxies to establish a star formation rate (SFR) indicator using 70micron emission for sub--galactic (<0.05-2 kpc) line-emitting regions and to investigate limits in application. A linear correlation between 70micron and SFR is found and a star formation indicator SFR(70) is proposed for line-emitting sub-galactic regions as σ (SFR) (M_$\odot$· yr^-1·kpc^-2)=9.4(±3.3)× 10^-44 σ (70) (ergs· s^-1· kpc^-2), for regions with 12+log(O/H) >~8.4 and σ (SFR) >~10^-3 (M_$\odot$·yr^-1\· kpc^-2), with a 1-σ dispersion around the calibration of ~0.16~dex. We also discuss the influence of metallicity on the scatter of the data. Comparing with the SFR indicator at 70micron for integrated light from galaxies, we find that there is ~40\%$ excess 70micron emission in galaxies, which can be attributed to stellar populations not involved in the current star formation activity.

Guilin Liu (University of Massachusetts)

The Super-Linear Slope of the Spatially-Resolved Star Formation Law in NGC 3521 and NGC 5194 (M51a)

We have conducted interferometric observations with CARMA and an OTF mapping with the 45-m telescope at NRO in the CO (1-0) emission line of NGC 3521. Combining these new data, together with similar data for M51a and archival SINGS H-alpha, 24um, THINGS H I and GALEX FUV data for both galaxies, we investigate the empirical scaling law that connects the surface density of star formation rate (SFR) and cold gas (the Schmidt-Kennicutt law) on a spatially-resolved basis, and find a super-linear slope when carefully subtracting the background emissions in the SFR image. We argue that plausibly deriving SFR maps of nearby galaxies requires the diffuse stellar/dust background emission to be carefully subtracted (especially in mid-IR). An approach to complete this task is presented and applied in our pixel-by-pixel analysis on both galaxies, showing that the controversial results whether the molecular S-K law is super-linear or basically linear is a result of removing or preserving the local background. In both galaxies, the power index of the molecular S-K law is super-linear (1.5-1.9) at the highest available resolution (230 pc), and decreases monotonically for decreasing resolution; while the scatter (mainly intrinsic) increases as the resolution becomes higher, indicating a trend for which the S-K law breaks down below some scale. Both quantities are systematically larger in M51a than in NGC 3521, but when plotted against the de-projected scale, they become highly consistent between the two galaxies, tentatively suggesting that the sub-kpc molecular S-K law in spiral galaxies depends only on the scale being considered, without varying amongst spiral galaxies. We obtain slope=-1.1[log(scale/kpc)]+1.4 and scatter=-0.2 [scale/kpc]+0.7 through fitting to the M51a data, which describes both galaxies impressively well on sub-kpc scales. However, a larger sample of galaxies with better sensitivity, resolution and broader FoV are required to test these results.

Anthony P. Marston (ESA)

Newly Discovered Evolved Massive Stars and Their Environments

A.P.Marston(1), J. Mauerhan(2), P. Morris(2), S. Van Dyk(2) 1 Herschel Science Centre, ESAC, Madrid, Spain 2 IPAC, Caltech, CA, USA

In recent years we have been able to use Spitzer and 2MASS data to identify evolved massive star candidates. Confirmation via near-infrared spectroscopy has enabled the verification of evolved massive star status of candidates and Wolf-Rayet stars, in particular. In this presentation we discuss the galactic distribution of new Wolf-Rayet stars and look to determine new insights on their mass-loss history via studies of their mid- and far-infrared environments. We also search for mid- to far-infrared excesses indicative of more recent heavy mass-loss from the stars. A number of evolved massive stars are found well away from major star forming centres making direct association of circumstellar features more reliable.

Douglas J. O'Rourke (University of Cambridge)

Evolutionary Models of Infrared Galaxy Spectra

We use the galaxy model of Shabala et al. (2009) to predict the star formation histories for a range of halo masses. From this and the mass loss yields predicted by the starburst99 package (Leitherer et al. 1999) we follow the chemical evolution of the ISM and hence determine the dust masses present. The dust is distributed between star forming regions and the diffuse ISM in a way consistent with the galaxy model, by considering the star formation efficiency of the molecular clouds. Input stellar spectra to be processed through a radiative transfer model are produced by convolving the star formation histories with starburst99 spectra. We use the dust radiative transfer model presented in Ford et al. 2008. In the computational trade off between the complex geometrical distribution of dust and stars and the detailed dust grain energetics, this model simplifies the geometry in order to utilize the latest dust models as described by Draine and Li (2007). The model has been validated by fitting to IR photometric data from Spitzer for a sample of local galaxies and demonstrating that it successfully reproduces star formation rates and dust masses as determined by other techniques. This enables us to predict the synthetic spectra of a single galaxy to high redshift and determine how it evolves, as shown in the attached figure. When this is done for all halo masses we can predict luminosity functions for a given redshift and photometric passband, to compare with observational data. The wavelengths and sensitivities of the PACS and SPIRE photometric passbands of Herschel are ideal for conducting this work at higher redshifts, complementing work already done by Spitzer at low redshift.

Nurur Rahman (University of Maryland)

Coupling between Diffuse Emission and Star Forming HII Regions and Its Impact on Gas - Star Formation Surface Density Relation

Besides emission from localized star forming HII regions, a galaxy brightness distribution contains a diffuse component which is extended over the entire disk and not necessarily associated with recent/current star formation (SF) activity. Diffuse emission (DE) makes a significant fraction (~30-50%) of total emission in FUV, optical, and mid-IR 24 micron and integrated with that from HII regions in a complex manner. However, since the calibration of SF rate tracers is performed in star forming regions, it is essential to remove the contribution from DE to the brightness distribution before interpreting it in terms of SF rate. We have carried out a systematic study to disentangle the contribution of diffuse ISM from total emission to understand its impact on spatially resolved (200-480 pc) gas - SF surface density relation (commonly known as Schmidt-Kennicutt relation). An improved modeling effort of galaxy formation and evolution requires a better understanding of the gas-SF surface density relation at small spatial scale. Our study based on three nearby galaxies including NGC5194 (M51), NGC628 (M74), and NGC4254 (M99) suggests that observational constraint on the functional form of gas-SF surface density relation requires an accurate estimate of diffuse fraction. Our study demonstrates that a strongly non-linear relationship arises because of over subtraction (removal) of DE from low surface brightness regions. However, gas surface density scales linearly with SF rate if DE is negligible in the disk. We find that a linear relationship stems from the strict assumption that DE essentially comprises ionizing photons leaking from HII regions. This assumption is debated as observational studies suggest that the properties of diffuse ISM is markedly different than HII regions. Our study concludes that an improper treatment of the components of ISM biases the inference of the functional relationship between gas-SF surface densities.

Letizia Stanghellini (NOAO)
Dust and Gas Evolution in Galactic and Extragalactic Planetary Nebulae: the Spitzer View
Large samples of Galactic disk and Magellanic Cloud planetary nebulae (PNe) have been observed with IRS/Spitzer to disclose their dust and gas properties. Together with a parallel study of HST images we correlate the evolutionary stages of the PNe to their progenitor mass and metallicity for insight on cosmic recycling and dust evolution in low mass stars.

Johannes G. Staguhn (Johns Hopkins University & NASA/GSFC)
Observations of High-z Galaxies with GISMO, a 2 mm Bolometer Camera for the IRAM 30 m Telescope
We have demonstrated a monolithic 8x16 Backshort Under Grid (BUG) array with superconducting Transition Edge Sensors (TES), using our 2 mm wavelength imager GISMO (Goddard IRAM Superconducting 2 Millimeter Observer) at the IRAM 30 m telescope in Spain for astronomical observations. The 2 mm spectral range provides a unique terrestrial window enabling ground-based observations of the earliest active dusty galaxies in the universe and thereby allowing a better constraint on the star formation rate in these objects. GISMO is optimized for detecting sources serendipitously in large sky surveys, while the capability for diffraction limited imaging is preserved. The camera provides significantly greater detection sensitivity and mapping speed at this wavelength than has previously been possible. The instrument fills in the spectral energy distribution of high redshift galaxies at the Rayleigh-Jeans part of the dust emission spectrum, even at the highest redshifts. Here we present astronomical results obtained during recent observing runs.

Sabrina Stierwalt (SSC/Caltech)
Mid-Infrared Properties of Luminous IR Galaxies: The Effects of Star Formation and AGN on PAHs at z=0
Nearby Luminous Infrared Galaxies (LIRGs) act as local analogs of the extreme star-forming environments that dominate star formation at z~1 and thus play a central role in our understanding of galaxy evolution. We present the global properties of the polycyclic aromatic hydrocarbon (PAH) emission (a well-known tracer of star formation) for the GOALS sample of 182 LIRGs and 20 ULIRGs. As a far IR-selected sample, GOALS probes a larger range of dust extinction than previous PAH studies, and its multi-wavelength nature allows for comparisons between PAH emission and other galaxy properties such as dust temperature, IR/UV excess (IRX), and merger stage. Using low resolution spectroscopy from Spitzer IRS and a multi-component SED decomposition method (CAFE), we find, despite the large range of galaxy types, a nearly uniform dust signature when the MIR emission is starburst dominated. However, for low equivalent width sources, the PAH band ratios vary by as much as a factor of 5, and we combine the results derived from our detailed fitting technique with data from other wavelengths to explore the causes of the scatter in these ratios.

Konstantinos Tassis (JPL)
Coupling Chemistry and Dynamics of Molecular Cloud Cores
We present a study of the coupling between chemistry and dynamics for a variety of evolving prestellar molecular cloud core models, aimed at probing the initial conditions of star formation. We follow the dynamical evolution of prestellar molecular cloud cores under different assumptions (such as pure hydrodynamical collapse; magnetically modulated collapse; and non-collapsing oscillating cores). We have coupled these models to a non-equilibrium network of chemical reactions (including gas-grain interactions and grain surface reaction) that self consistently follows the relative abundances of more than 100 molecular species in space and in time, by solving the chemical reactions simultaneously with the dynamical equations. The convolution of our results with the instrumental capabilities of different observatories (such as Herschel, SOFIA, and ALMA) can produce sets of mock observations, which will allow us to: (a) assess the potential of observations with different instruments to differentiate between models for the dynamics of prestellar cores; (b) propose specific observations with maximal scientific return in the discrimination between dynamical models; and (c) for existing observations, offer interpretation in terms of their consistency with each dynamical model examined.

Jia-Wei Wang (National Tsing Hua University, Taiwan)
Evaluating the Relative Importance of the Photoevaporation and Homologously Depleted Processes in the Evolution of Transition Circumstellar Disks
We perform a statistical analysis on the morphology of the spectral energy distributions (SEDs) in circumstellar disks to exam the disk evolution theories. Currie et al. (2009) suggests that at least two evolution paths exist in transition disks, homologously depleted disks and disk with inner holes (canonical transition disks). To evaluating the relative importance of the photoevaporation and homologously depleted processes in the evolution of transition disks, we investigating the relative population of transition disks

from the Spitzer Core to Disk (c2d) Legacy Project. The transition disks are classified by comparing the data to the SED models. The SED models for the homologously depleted disks, canonical transition disks and primordial disks are obtained from Robitaille et al. (2006) using the classification criteria in Currie et al. We discover that the distribution of SED models for the three type of disks occupy different regions in Alpha_excess ¨Lambda_turnoff˙ space. Lambda_turnoff is the wavelength where the disk flux is equal to the stellar flux and Alpha_excess is the spectral slope at wavelength longer than Lambda_turnoff, and the c2d YSO candidates can be classified by their locations on the Alpha_excess-Lambda_turnoff diagram. We show that the population ratio of homologously depleted disks to canonical transition disks is 4.7, 7.2, 4.5, 5.2 and 2.8 in Chamaeleon II, Lupus, Ophiuchus, Persues and Serpens. The results suggest that the homologously depleted disks are more common or have longer lifetime than canonical transition disks. In addition, we find that the evolutionary path derived from a homologously depleted model (Wood et al. 2002) on the Alpha_excess-Lambda_turnoff diagram is located within the distribution of homologously depleted disk data, whereas the photoevaporation model (Alexander et al. 2006) does not show clear path from primordial disks to canonical transition disks likely due to the insufficient time steps in the calculations.

Kyle Willett (University of Colorado)
IRS Observations of OH Megamaser Galaxies
We present mid-infrared spectra for a sample of 51 OH megamaser (OHM) galaxies obtained with the IRS onboard the Spitzer Space Telescope. The hosts of the OHMs, which are merging ULIRGs, comprise a relatively uniform sample in the mid-IR - all show 9.7 um silicate absorption, multiple fine-structure and H2 lines, and PAH emission. When compared to a control sample of non-masing ULIRGs, however, the IRS data reveal significant differences between the two populations. OHMs show significantly deeper silicate absorption, steeper continuum slopes between 20 and 30 microns, and much higher detection rates of crystalline silicates, water ice, hydrocarbons, and OH absorption than the non-masing galaxies. We compare the observed properties to radiative transfer models (Lockett & Elitzur 2008) that predict the OHM strength. While measured dust temperatures of 40-80 K agree with the model, we show that a much higher optical depth (tau_V of several hundred) is required to produce an OHM, contradicting the several tens of tau_V predicted in their model. These IRS results represent the first detailed test of an OHM model based only on the observed properties of the host galaxy, and provide new restrictions on the physical conditions necessary for maser production. This is an important step toward understanding the relationship between radio and mid-IR properties of ULIRGs, showing potential for future use of OHMs as tracers of major mergers and extreme star formation at cosmic distances.

Ronin Wu (New York University)
The Spitzer SDSS Spectroscopic Statistical Survey (S5) - Molecular Hydrogen Mass Function
Molecular hydrogen is the simplest and most abundant molecule in the Universe. The abundance of molecular hydrogen is a direct indicator for the star--forming ability of galaxies. I present the first mass function of molecular hydrogen directly measured using

the molecule's rotational lines in the mid-infrared for galaxies in the homogeneously selected, S5 sample.

Yanling Wu (Caltech/IPAC)

The Luminosity and Luminosity Function from 5MUSES

We study a 24um selected sample of 330 galaxies observed with the Infrared Spectrograph for the 5mJy Unbiased Spitzer Extragalactic Survey (5MUSES). The redshifts of 5MUSES span a range from 0.008 to 4.27, with a median of 0.144. We have estimated accurate total infrared luminosities using a combination of mid-IR spectroscopy and mid-to-FIR photometry and we provide our calibration of using continuum luminosity or PAH luminosity to estimate L(IR) for different types of objects. Local 15 and 24um luminosity functions at z<0.3 have been derived for the 5MUSES sample. The availability of 5-35um IRS spectrosocpy also allows us to decompose the AGN and SF contribution in the mid-IR SED for each object and derive the mid-IR star-formation luminosity. Finally, we estimate the mid-IR luminosity density of star formation and AGN in the local universe.

Instrumentation and Outreach

Dominic J. Benford (NASA GSFC)
A Selection of Early Extragalactic Science Results from WISE
NASA's Wide-field Infrared Survey Explorer (WISE) has mapped the entire sky at 3.4, 4.6, 12, and 22 microns with sensitivity hundreds of times better than that of predecessor surveys by IRAS and the DIRBE instrument on COBE, and with much better angular resolution. Preliminary WISE data products covering 55% of the sky will be released in April 2011, in time for the community to propose scientific investigations based on WISE data analysis under NASA's ROSES/ADAP program. The WISE team is currently engaged in many research studies, including the sample of extragalactic science projects featured here.

Matt Bradford (JPL Astrophysics / Caltech Submillimeter Astronomy)
The Background-Limited Infrared Submillimeter Spectrograph (BLISS) for SPICA
We are developing the Background-Limited Infrared-Submillimeter Spectrograph (BLISS) for SPICA to provide a breakthrough capability for far-IR survey spectroscopy. SPICA's large cold aperture allows mid-IR to submm observations which are limited only by the natural backgrounds, and BLISS is designed to operate near this fundamental limit. BLISS-SPICA is 6 orders of magnitude faster than the spectrometers on Herschel and SOFIA in obtaining full-band spectra. It enables spectroscopy of dust-obscured galaxies at all epochs back to the first billion years after the Big Bang (redshift > 5), and study of all stages of planet formation in circumstellar disks. US participation in SPICA with an instrument such as BLISS represents the top priority of the far-IR astrophysics community for the coming decade, and is one of the top recommendations of the recent Astro2010 Decadal Survey.

BLISS covers the 38-433 micron range in five grating-spectrometer bands, and couples two positions on the sky simultaneously. The instrument is cooled to 50 mK for optimal sensitivity with an on-board dual-stage sorption + adiabatic demagnetization refrigerator (ADR). The detector package is 4224 silicon-nitride micro-mesh leg-isolated bolometers with superconducting transition-edge-sensed (TES) thermistors, read out with a cryogenic time-domain multiplexer. All technical elements of BLISS have heritage in mature scientific instruments, and many have flown. We report on our design study in which we are optimizing performance while accommodating SPICA's constraints, including the stringent cryogenic mass budget. We present the science case for BLISS, as well as our progress in key technical aspects: 1) opto-mechanical instrument architecture, 2) detector and readout approach, and 3) sub-K cooling approach.

Justin Howell (IRSA)
New Data and Services at the NASA/IPAC Infrared Science Archive (IRSA)
The NASA/IPAC Infrared Science Archive (IRSA) serves science data sets from NASA's infrared and submillimeter projects and missions. IRSA is the long term home for data from the Spitzer Space Telescope, through the Spitzer Heritage Archive (SHA). The SHA interface now replaces the "Leopard" software as the tool to access data from Spitzer. It provides complete access to data from both the warm and cryogenic data

missions, together with enhanced science products produced by the Spitzer Science Center and the Legacy teams.

IRSA is undergoing a period of rapid archive expansion with the addition of new data sets, along with new tools for serving them. In Spring 2011, IRSA will be the archive center for the Wide-field IR Survey Explorer (WISE) satellite, and will serve the Early Release Science Catalog from ESA's Planck mission to the US community. We highlight recent data additions to IRSA. We describe the web interface for the Spitzer Heritage Archive and future plans for multi-mission data access at IRSA. IRSA can be found at http://irsa.ipac.caltech.edu .

David Leisawitz (NASA GSFC)
WISE Image of The Week and Community Information
This poster features a new WISE "image of the week", with a web link to similarly-featured images and information about WISE for the astronomical community.

David Leisawitz (NASA GSFC)
A Medley of Early Galactic Science Results from WISE
NASA's Wide-field Infrared Survey Explorer (WISE) has mapped the entire sky at 3.4, 4.6, 12, and 22 microns with sensitivity hundreds of times better than that of predecessor surveys by IRAS and the DIRBE instrument on COBE, and with much better angular resolution. Preliminary WISE data products covering 55% of the sky will be released in April 2011, in time for the community to propose scientific investigations based on WISE data analysis under NASA's ROSES/ADAP program. The WISE team is currently engaged in many research studies, including the sample of Galactic science projects featured here.

Suzanne Madden (CEA, Saclay), the SAFARI consortium
Galaxy Evolution with SAFARI on SPICA
While the Herschel mission is opening up a new FIR (60-210 μm) band, and ALMA and JWST will provide a leap in both spatial resolution and sensitivity in the MIR and submillimeter, coverage of the full MIR/FIR band with high sensitivity and spatial resolution will still not have been achieved until the Japanese telescope, SPICA (SPace Infrared telescope for Cosmology and Astrophysics). SPICA is a Mission of Opportunity in ESA's Cosmic Vision Program with an expected launch in FY 2018 carrying the same size telescope as Herschel (3.5 m), but cooled to < 5 K, covering 25 to 210 μm.

We present the science capabilities for a far-IR instrument to be flown on SPICA. SAFARI, SpicA FAR-infrared Instrument, is an imaging spectrometer with both spectral and photometric capabilities covering the ~34-210mm waveband. The development is being undertaken by a consortium of European, Canadian and Japanese institutes. While SAFARI is a highly versatile instrument we highlight some of the science questions that will be addressed in the field of galaxy evolution and cosmology.

Luisa Rebull (SSC/IPAC)
Authentic Astronomy Research Experiences for Teachers: the NASA/IPAC Teacher Archive Research Program (NITARP)

How many times have you gotten a question from the general public, or read a news story, and concluded that "they just don't understand how real science works"? One really good way to get the word out about how science works is to have more people experience the process of scientific research. The way we have chosen to do this, since 2004, is to provide authentic research experiences for teachers using Spitzer data. (The program used to be called the Spitzer Teacher Program for Teachers and Students, and has been rechristened NITARP, the NASA/IPAC Teacher Archive Research Program.) We partner small groups of teachers with a mentor astronomer, they do research as a team, write it up, and present it at an American Astronomical Society (AAS) meeting. The teachers incorporate this experience into their classroom, and their experiences color their teaching for years to come, influencing 100s of students per teacher. Please see our website for more information:
http://coolcosmos.ipac.caltech.edu/cosmic_classroom/teacher_research/

Gordon K. Squires (Caltech/IPAC/SSC & NHSC)
The Other 99.99%

If you build it, they will come." This phrase from the film "Field of Dreams" also applies to our preconceptions for the popularity of astronomical imagery. We think (hope?) that the dazzling images produced by both ground- and space-based telescopes are surely so compelling that all we need to do is make them available, and the world will rush to revel in their wonders. Fancy websites and social media including Twitter, Facebook, Flikr, YouTube are common vehicles to share astronomical images, and convey the latest astronomical news and discoveries. But who exactly are we reaching? In this poster, we will examine shortcomings in current strategies, and propose an alternative way for reaching "the other 99.99%" of the population.