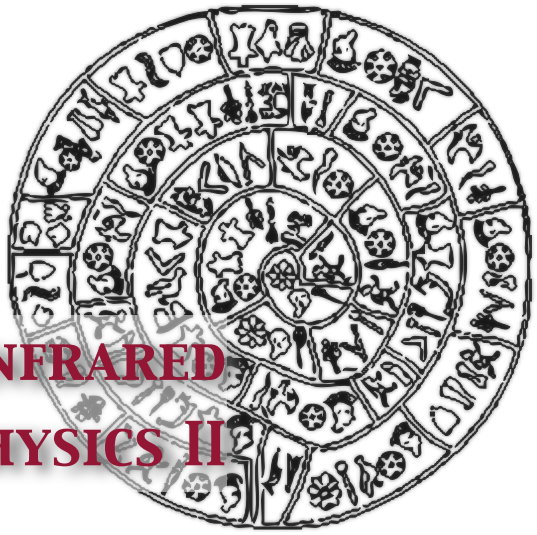
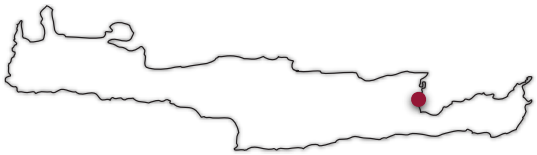
Challenges in Infrared Extragalactic Astrophysics II





Agios Nikolaos, Crete, Greece
September 26th - October 1st, 2010

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FOREWORD

"If you are not prepared for the unexpected you will never discover it."
Heraclitus

The scope of this 5 day conference is to bring together experts on Infrared Extragalactic Astrophysics to discuss the outstanding questions in the field as well as how planned experiments using future facilities may address them. Emphasis will be given on how one can apply the knowledge derived from studies of the local universe to understand the properties of galaxies at higher redshifts.

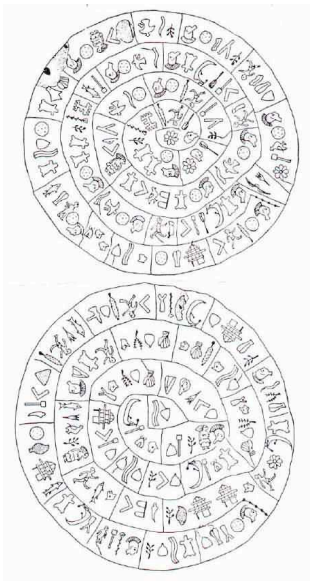
Funding and support for the workshop is provided by the "ASTROSPACE" European Union 7th Framework Programme.

Scientific Organizing Committee

- Lee Armus, Spitzer Science Center, Caltech, USA
- Catherine Cesarsky, CEA/Saclay, France
- Vassilis Charmandaris, University of Crete & FORTH/IESL, Greece
- David Elbaz, CEA/Saclay, France
- Alberto Franceschini, Univ. of Padova, Italy
- George Helou, Caltech, USA
- Nick Kylafis, University of Crete & FORTH/IESL, Greece
- Emeric Le Floc'h, CEA/Saclay, France
- Dieter Lutz, MPE, Germany
- J.D. Smith, Univ. of Toledo, USA
- Paul van der Werf, Leiden Observatory, The Netherlands
- Laurent Vigroux, IAP, France

Local Organizing Committee

Thodoris Bitsakis, Vassilis Charmandaris, Elisabete da Cunha, Tanio Díaz-Santos



Cover Figure - The Phaistos Disc: The Phaistos Disc was found in 1908 at the ruins of the earlier Minoan palace of Phaistos in Crete, Greece. The exact age of the disk is uncertain, but it probably dates from the MM IIB period (17th century BC). It was made of clay, its average diameter is 16 cm and it is 2.1 cm thick. Its mysterious inscription constitute 241 symbols, 122 on side A and 119 on side B, in spiral order. There appear 45 distinct symbols (with repetitions). Those symbols were actually impressed on wet clay and then the disk was fire-hardened. The signs belong to an ideographic and probably syllabic script, which has not yet been deciphered despite the numerous attempts over the years. Researchers have proposed widely diverse speculations about the purpose, the contents of its inscription and its creators.

This has made the Phaistos Disc a real challenge for archaeologists and this is the reason why the Disc has been chosen by the Foundation for Research and Technology - Hellas (FORTH) as its symbol, as it expresses exactly the same challenges scientists encounter every day during their research.

List of Participants

Participant	Institution	Country
David **Alexander**	Durham University	UK
Almudena **Alonso-Herrero**	CSIC-Madrid	Spain
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Paul **van der Werf**	Leiden Observatory	The Netherlands
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Hans **Zinnecker**	Deutches SOFIA Inst. & NASA Ames	Germany

Conference Program

Sunday - September 26th, 2010			
18:00	20:00		Registration
20:00	21:30		Welcome cocktail

Monday - September 27th, 2010			
		Session I: Probing Infrared-Luminous Systems **Chair: D. Lutz**	
08:15	09:00		Registration
09:00	09:10	V. Charmandaris	Welcome
09:10	**09:50**	**L. Armus**	**Multiwavelength properties of Luminous and Ultraluminous Infrared Galaxies**
09:50	**10:30**	**A. Alonso-Herrero**	**Extended star formation activity in local Luminous Infrared Galaxies: ionizing photons, dust, PAHs and molecular gas**
10:30	**11:10**	**P. van der Werf**	**The look of Hercules**
11:10	**11:40**		**Coffee Break**
11:40	12:10	R. Meijerink	Determining sources of excitation in the center of active galaxies
12:10	**12:50**	**G. Stacey**	**Far-IR Fine-structure Line Emission from High Redshift Galaxies**
12:50	**13:40**	**P. Appleton**	**Molecular Line Cooling: From Nearby Galaxies to High Redshift**
13:40	**17:00**		**Afternoon break**
		Poster Session **Chair: V. Charmandaris**	
17:00	19:00		Up to 30 poster presentations (~3 min each poster)
19:00	**20:00**		**Coffee Break / Discussion**

Tuesday - September 28th, 2010

Session II: Environment & Statistical Properties of Galaxies
Chair: M. Dickinson

09:00	**09:40**	**N. Scoville**	**Large Scale Structure and Galaxy Evolution**
09:40	10:10	H.S. Hwang	Environmental Effects on Local Luminous Infrared Galaxies
10:10	10:40	E. Le Floc'h	Rest-frame UV morphology of Herschel-selected ULIRGs at z~1-3
10:40	11:10	E. Egami	Herschel Observations of Galaxy Clusters: Gravitationally Lensed Galaxies and IR/Submm-Bright Cluster Members
11:10	**11:40**		**Coffee Break**
11:40	**12:10**	**D. Elbaz**	**The Growth of Galaxies as seen by Herschel**
12:10	12:40	T. Goto	Cosmic star formation history and AGN evolution near and far: AKARI reveals both
12:40	13:10	Y. Wu	The IR luminosity and the Local mid-infrared luminosity function from the 5mJy Unbiased Spitzer Extragalactic Survey
13:10	13:40	L. Marchetti	The SWIRE-SDSS database & the Spitzer/ Herschel Local Luminosity Function
13:40	**17:00**		**Afternoon Break**

Session III: Local Analogues
Chair: N. Kylafis

17:00	**17:40**	**J.D. Smith**	**Dust and Gas Cooling in the Nearby Universe: Herschel's KINGFISH**
17:40	18:10	M. Sauvage	A view from the thermal IR peak: classic galaxies in the Herschel era
18:10	**19:00**		**Open Discussion**
20:30	**00:00**		**Conference Dinner**

Wednesday - September 29th, 2010

Session IV: Finding the AGN
Chair: E. Le Floc'h

09:00	**09:40**	**E. Sturm**	**Infrared AGN Diagnostics**
09:40	**10:20**	**D. Alexander**	**The Quest for a Complete Census of AGN Activity: Challenges and Progress**
10:20	10:50	E. Hatziminaoglou	FIR properties of AGN in the HerMES fields
10:50	**11:20**		**Coffee Break**
11:20	**12:00**	**D. Lutz**	**A Herschel view on the coevolution of galaxies and AGN**
12:00	12:30	A. Pope	Disentangling star formation and active galactic nuclei activity over cosmic time
12:30	13:00	S. Juneau	Absorbed Active Galactic Nuclei Among 70μm - Selected Galaxies
13:00	13:30	V. Desai	The dirt on dry mergers
13:30	**19:00**		**Afternoon Free**

Thursday - September 30th, 2010			
Session V: Dust and gas at high redshifts **Chair: D. Elbaz**			
09:00	**09:40**	**E. Daddi**	**Different star formation modes in distant massive galaxies**
09:40	**10:10**	**L. Tacconi**	**Dynamics and High Cold Gas Fractions in Star Forming Galaxies at z=1-3**
10:10	10:40	Y. Gao	The far-IR - dense molecular gas correlation in galaxies
10:40	11:10	A. Karim	The star formation history of mass-selected galaxies in the COSMOS field: The radio-IR relation as a key to understanding galaxy evolution
11:10	**11:40**		**Coffee Break**
11:40	12:10	B. Magnelli	Far-Infrared Properties of Submillimeter and Optically Faint Radio Galaxies
12:10	12:40	M. Michalowski	Dust grain growth in the interstellar medium of galaxies at redshifts 4<z<6.5
12:40	13:10	G. Magdis	Towards a complete census of high-z ULIRGs with Herschel
13:10	13:40	H. Shim	The Broad Hint for dust extinction of star-forming galaxies at z>4
13:40	**17:00**		**Afternoon Break**
Session VI: Theoretical Modelling **Chair: A. Franceschini**			
17:00	17:30	C. Hayward	Do submillimeter galaxy number counts provide evidence for an evolving IMF?
17:00	18:00	C. Lacey	Evolution of galaxies in the IR in CDM galaxy formation models
18:00	18:30	E. da Cunha	Ultraviolet-to-infrared SED modelling of local (U)LIRGs
18:30	**19:00**		**Coffee Break**
19:00	19:30	C. Popescu	Modelling the spectral energy distribution of galaxies
19:30	20:00	R. Siebenmorgen	AGN dust model of high redshift 3CR sources

Friday - October 1st, 2010

Session VII: Infrared Background & Future Missions
Chair: J.D. Smith

09:00	**09:40**	**H. Dole**	**Unveiling the Cosmic Infrared and Submillimeter Backgrounds**
09:40	10:10	M. Viero	Lessons Learned from BLAST
10:10	10:40	P. Eisenhardt	Extragalactic Astrophysics with the Wide-field Infrared Survey Explorer
10:40	**11:10**	**H. Matsuhara**	**Challenges with SPICA**
11:10	**11:40**		**Coffee Break**
11:40	12:00	L. Spinoglio	MIR/FIR Spectroscopy of AGN and starburst along galaxy evolution with SPICA-SAFARI
12:00	**12:30**	**L. Vigroux**	**Conference Summary**
12:30	**12:40**	**V. Charmandaris**	**Closing Remarks**

Poster Presentations

P#	Presenter	Poster Title
1	H. Aussel	*Green Valley Galaxies: Extincted Starbursts or Evolving Post Starburst?*
2	P. Beirão	*Far-Infrared Line Imaging of the Starburst Ring in NGC1097*
3	T. Bitsakis	*Infrared properties of compact groups of galaxies. How the environment affects galaxy evolution.*
4	J. M. Cannon	*Spatially Resolved PAH Emission Features in Nearby Star-Forming Galaxies*
5	M. Cluver	*Powerful H_2 Line Cooling in Stephan's Quintet and other probes of Compact Group Evolution*
6	H. Dannerbauer	*Unveiling Far-Infrared Counterparts of Bright Submillimeter Galaxies Using PACS Imaging*
7	T. Díaz-Santos	*Spatially resolved (U)LIRGS in GOALS*
8	H. Dominguez-Sanchez	*Searching for the oldest and most massive galaxies at high z*
9	J. Fischer	*Ionized regions in ULIRGs: Dust-bounded, obscured, or partially covered outflowing structures*
10	J. Fritz	*Herschel Virgo Cluster Survey*
11	E. González-Alfonso	*Herschel observations of water vapour in Markarian 231*
12	B. Groves	*Using nearby Star-forming regions to understand far: The case of 30 Doradus*
13	M. Haas	*High redshift (z=1.5) galaxy clusters*
14	A. Hernán-Caballero	*An atlas of mid-IR spectra of active galaxies; silicates in AGN and model implications.*
15	V. Lebouteiller	*PDRs in blue compact dwarf galaxies: the Herschel era*
16	M. Lemoine-Busserolle	*2D kinematics and physical properties of distant galaxies*
17	A.-L. Melchior	*K-corrections in optical and near-infrared*

P#	Presenter	Poster Title
18	A. Medling	*Using Adaptive Optics to study (U)LIRG Mergers in the Nearby Universe*
19	C. Ramos Almeida	*Testing the unification model for AGN in the infrared: are the obscuring tori of Type 1 and 2 AGN different*
20	J. Rawlings	*Coeval Star Formation and Black Hole Growth in the Most Massive Galaxies*
21	M. Rex	*The far-infrared/submillimeter properties of galaxies located behind the Bullet cluster*
22	N. Rodríguez-Eugenio	*Testing the suitability of infrared luminosity as a reliable star formation rate indicator at z~1*
23	P. Santini	*The dust content of high-z submillimeter galaxies revealed by Herschel*
24	S. Stierwalt	*Mid-IR Properties of Luminous IR Galaxies: The Effects of Star Formation and AGN on PAHs at z=0*
25	M. Vaccari	*Spitzer Extragalactic Representative Volume Survey (SERVS) Early Science*
26	E. Vardoulaki	*The K-z relation and the radio structure of the TOOT00 and the SXDS radio sources*
27	K. Willett	*Mid-infrared triggers for OH megamaser production*
28	E. Xilouris	*The far-infrared continuum of M33*
29	A. Zezas	*Infrared Study of an Interacting Galaxy sample*

Abstracts – Oral Contributions

Multiwavelength properties of Luminous and Ultraluminous IR galaxies

L. Armus

IRAS provided our first complete look at the far-infrared sky, allowing us to identify extremely luminous galaxies that emit the bulk of their energy in the infrared. First with ISO and most recently with Spitzer, we have been able to systematically probe the physical conditions in samples of luminous infrared galaxies at low redshift, discover large populations at high redshift, and firmly establish the relationship between starburst activity and black hole growth over a wide range of cosmological epochs. Early, exciting results from Herschel promise to further revolutionize our understanding of the dynamic ISM in normal and luminous infrared galaxies. I will review the most important recent advances in our study of LIRGs and ULIRGs, discuss some unsolved problems, and briefly look to the future when the next generation of far-infrared and sub-mm observatories (ALMA, SPICA, CCAT) will open new windows on the study of LIRGs and ULIRGs on the smallest scales and at the highest redshifts.

Extended star formation activity in local Luminous Infrared Galaxies: ionizing photons, dust, PAHs and molecular gas

A. Alonso-Herrero, M. Pereira-Santaella, S. Garcia-Burillo, G. H. Rieke, J. Gracia-Carpio, L. Colina

In this talk I will present HST/NICMOS Paα, Spitzer and IRAM observations of a sample of local (d<75Mpc) Luminous Infrared Galaxies (LIRGs, $L_{IR}=10^{11}$-10^{12} L_{sun}). The star formation activity, as probed by the Paα and [NeII]+[NeIII] emission lines, the PAH features and mid-IR continuum emissions, is distributed in multiple dusty regions spread over several kiloparsecs. The high angular resolution Paα imaging shows a large diversity of morphologies, from compact (<1 kpc) nuclear emission, to nuclear (scales 1-2 kpc) mini-spirals and rings of star formation, to galaxies where most of the emission is in HII regions along the spiral arms. There is a large range of mid-IR nuclear concentrations (=f(2kpc)/f(total)~0.1-0.9 at 8μm and PAH emission) with no correlation with the IR luminosity of the system or activity class This is in contrast with local Ultraluminous Infrared Galaxies (ULIRGs, $L_{IR}>10^{12}$ L_{sun}) where most of the mid-IR emission arises from the central ~500pc or less. I will also show that the integrated mid-IR spectra of local LIRGs are remarkably similar to those of high-z ULIRGs, which further supports the interpretation of extended star formation in high-z ULIRGs. I will finally combine these observations to study the star formation efficiency and star formation laws in galaxies.

HerCULES peers into the dark hearts of luminous infrared galaxies

P. van der Werf

Luminous and ultraluminous infrared galaxies ((U)LIRGs) are among the most spectacular objects in the local universe as far as their energy output is concerned. While they are locally fairly rare, star formation becomes more and more dominated by these galaxies as we look back towards higher redshifts. Optical studies of the energy sources of (U)LIRGs are hampered by their large obscuring column densities of dust, but the concomitant molecular gas provides unique probes of local conditions in far-infrared and submillimetre spectral lines. These lines will become key diagnostics of high-z galaxies in the ALMA era, and it is therefore imperative to understand them in local galaxies.
With this in mind, we have embarked on the Herschel Comprehensive (U)LIRG Emission Survey (HerCULES), an Open Time Key Program on the Herschel Space Observatory, which will ultimately obtain full 194-671μm spectra (plus spectra of the principal infrared cooling lines at shorter wavelengths) of a complete sample of 29 (U)LIRGs. I will discuss first results of HerCULES and related projects, including (i) the use of the CO rotational ladder and other lines to separate star formation and AGN power; and (ii) the H2O rotational lines as probes of local physical conditions. I will also describe current efforts to develop the use of these lines to measure radiative and mechanical feedback in galactic nuclei.

Determing sources of excitation in the center of active galaxies

R. Meijerink

The recent launch of Herschel opened a new window in extragalactic astronomy and it is now feasible to observe for example the CO rotational ladder to J >= 13. Recent observations of Mrk 231 in combination with state-of-the-art PDR and XDR modelling allows us to make estimates of the AGN and starburst contribution to the energy input into the ISM in these systems. I will present a PDR/XDR analysis of a number of recent observations from the HerCULES and HexGal programs, and discuss prospects for the study of high redshift counterparts.

Far-IR Fine-structure Line Emission from High Redshift Galaxies

G. Stacey

Using our submillimeter grating spectrometer ZEUS on the CSO we have detected the 158μm [CII] line from a group of 13 galaxies in the redshift interval from 1 to 2, and the 88μm [OIII] line from two galaxies at z ~ 2.8 and 3.9. These lines are important cooling lines for the neutral and ionized ISM in galaxies, and trace the physical conditions of the gas and strength and hardness of the local UV radiation fields. We will discuss the results of our survey and the implications for star formation and its relationship to AGN activity in the early Universe.

Molecular Line Cooling: From Nearby Galaxies to High Redshift

P. Appleton

I will present Spitzer IRS and Herschel PACS and SPIRE spectroscopy of galaxies in the nearby universe. I will review observations of powerful H_2 emission from the Stephan's Quintet and the Taffy galaxies, as well as new results on a large survey of compact groups. The observations will emphasize the unusually high luminosity in these lines compared with the bolometric luminosity of dust and PAH emission in the galaxies. The results will be placed in context of other H_2 observations of radio galaxies and cool cluster core galaxies. I will tie these observations to new Herschel results on molecular outflows in ULIRGs using Herschel. Finally I will discuss prospects for future ground and space-based missions (JWST, SPICA, ALMA) to extend this kind of work to the epoch of the formation of the first galaxies and quasars at $z > 5$.

Large Scale Structure and Galaxy Evolution

N. Scoville

Extensive observations at z < 3 have clearly demonstrated the most significant role played by large scale structure environment in speeding the formation of the first galaxies. I will describe these key data from the COSMOS survey showing both the evolution of large scale structures and environmentally correlated galaxy evolution.

Environmental Effects on Local Luminous Infrared Galaxies

H. S. Hwang

Thanks to the recent wide/deep-field galaxy surveys such as the Sloan Digital Sky Survey (SDSS) and the Great Observatories Origins Deep Survey (GOODS), the environmental effects on the star formation activity of normal galaxies and its evolution have been extensively studied. However, there have been only a few studies focusing on how luminous infrared galaxies (LIRGs) and ultraluminous infrared galaxies (ULIRGs) are affected by the environment.

We present the results of the study of the environmental dependence of local LIRGs and ULIRGs found in SDSS. We examine the effects of three kinds of environment indicators on the properties of infrared galaxies (IRGs): the large-scale background density, galaxy clusters, and the nearest neighbor galaxy. We find that the fraction of LIRGs plus ULIRGs among IRGs ($f_{(U)LIRGs}$) and the infrared luminosities (L_{IR}) of IRGs strongly depend on the morphology of and the distance to the nearest neighbor galaxy: the probabilities for an IRG to be a (U)LIRG and its L_{IR} both increase as it approaches a late-type galaxy, but decrease as it approaches an early-type galaxy (within half of the virial radius of its neighbor). We find no dependence of $f_{(U)LIRGs}$ on the background density (surface galaxy number density) at fixed stellar mass of galaxies. The dependence of $f_{(U)LIRGs}$ on the distance to galaxy clusters is also found to be very weak, but in highest-density regions such as the center of galaxy clusters, few (U)LIRGs are found.

These environmental dependence of (U)LIRGs and the evolution of star formation rate-environment relation from high redshifts to low redshifts seem to support the idea that galaxy-galaxy interactions/merging play a critical role in triggering the star formation activity of (U)LIRGs.

Rest-frame UV morphology of Herschel-selected ULIRGs at z~1-3

E. Le Floc'h

Based on HST/ACS data I will present an analysis of the rest-UV morphology of high-z ULIRGs detected at 1<z<3 with Herschel. While the selection of distant ULIRGs at mid-IR or submillimeter wavelengths (e.g., Spitzer, SCUBA, AzTEC, MAMBO) had been potentially biased by dust temperature effects, Herschel is now opening a less biased window on the diversity of IR properties characterizing these sources. In particular, I will explore if variations linked to the temperature and/or the presence of nuclear activity is impacted on their UV morphology, and how this can be reconciled with our current knowledge of the physical mechanisms triggering the increase of star formation in such galaxies.

Herschel Observations of Galaxy Clusters: Gravitationally Lensed Galaxies and IR/Submm-Bright Cluster Members

E. Egami

One important component of Herschel extragalactic programs is observations of massive galaxy clusters. These observations will not only allow us to study the evolution of galaxies in a dense environment but also enable us to detect galaxies below the Herschel's confusion limit through the effect of gravitational lensing. In this talk, I will report the initial results from three open-time (OT) key programs: "The Herschel Lensing Survey" (PI: Eiichi Egami), "LoCuSS: A Legacy Survey of Galaxy Clusters at z=0.2" (PI: Graham Smith), and "Constraining the Cold Gas and Dust in Cluster Cooling Flows" (PI: Alastair Edge). The first program conducts deep PACS/SPIRE imaging of cluster cores and studies gravitationally lensed high-redshift galaxies while the second program performs wide-field (30'x30') PACS imaging of z~0.2 clusters and examines the IR/submm activities of cluster member galaxies. The third program carries out PACS/SPIRE photometry and PACS spectroscopy of the brightest cluster galaxies in so-called cooling-flow clusters. Together, these OT galaxy cluster programs will provide information on the properties and evolution of galaxies that are not accessible through blank-field surveys.

The Growth of Galaxies as seen by Herschel

D. Elbaz

Determining how and when did galaxies form their stars has been a challenge for modern astrophysics since their discovery. Great progress had been made in this field during the last fifteen years after the first version of the history of star formation at cosmic scales was proposed. Since then, it has appeared that the twofold representation of the star formation rate (SFR) as a function of cosmic time lacks other dimensions such as the impact of the environment, e.g. star formation timescales are accelerated in denser regions, or active nuclei (AGN). In particular, timescales of star formation for individual galaxies are not reflected by the average cosmic SFR history and the separation of spiral and ellipticals progenitors which formed their stars with long and short timescales respectively remains uncertain.

Until now studies of galaxy evolution have been severely limited by the uncertainties affecting the interpolations used to derive the bolometric output of galaxies, hence their SFR. The deepest extragalactic surveys with Herschel in the GOODS fields have been designed to overcome these limitations by sampling the 100 to 500μm range where the most active galaxies radiate the bulk of their light down to the confusion limit, hence providing information on typical and not only extreme galaxies. In combination with multiwavelength data from HST, Spitzer, Chandra and ground-based facilities such as IRAM, VLT and Keck, the first results of these surveys reveal a puzzling uniformity of star formation processes in galaxies over cosmic timescales. Two regimes of star formation are emerging, a continuous and a stochastic mode, in three independent diagrams providing a similar signature, for star forming galaxies, than the fundamental plane, for non star forming early-type galaxies, i.e. a sort of "fundamental tryptic" of star forming galaxies.

Cosmic star formation history and AGN evolution near and far: AKARI reveals both

T. Goto

Understanding infrared (IR) luminosity is fundamental to understanding the cosmic star formation history and AGN evolution, since their most intense stages are often obscured by dust. Japanese infrared satellite, AKARI, provided unique data sets to probe this both at low and high redshift; the AKARI all sky survey in 6 bands (9-160μm), and the AKARI NEP Deep survey in 9 bands (2-24μm).

AKARI performed all sky survey in 6 IR bands (9, 18, 65, 90, 140, and 160μm) with 3-10 times better sensitivity than IRAS, covering the crucial far-IR wavelengths across the peak of the dust emission. Combined with a better spatial resolution, AKARI can much more precisely measure the total infrared luminosity (L_{TIR}) of individual galaxies, and thus, the total infrared luminosity density of the local Universe.

In the NEP deep field, we construct restframe 8um, 12um, and total infrared (TIR) luminosity functions (LFs) at $0.15<z<2.2$ using 4128 infrared sources in the AKARI NEP-Deep field. A continuous filter coverage in the mid-IR wavelength (2.4, 3.2, 4.1, 7, 9, 11, 15, 18, and 24μm) by the AKARI satellite allows us to estimate rest-frame 8μm and 12μm luminosities without using a large extrapolation based on a SED fit, which was the largest uncertainty in previous work.

By combining these two results, we reveal dust-hidden cosmic star formation history and AGN evolution from $z=0$ to $z=2.2$, all probed by the AKARI satellite.

The IR luminosity and the Local mid-infrared luminosity function from the 5mJy Unbiased Spitzer Extragalactic Survey

Y. Wu, G. Helou, L. Armus, S. Stierwalt & the 5MUSES Team

We study a 24μm 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 24μm luminosity functions at z<0.3 have been derived for the 5MUSES sample. The availability of 5-35μm IRS spectroscopy 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.

The SWIRE-SDSS database & the Spitzer/Herschel Local Luminosity Function

L. Marchetti, M. Vaccari, A. Franceschini, SWIRE & HerMES

Infrared wavelengths contain a substantial amount of information about the origin of galaxies and active galactic nuclei and about the evolutionary history of star formation, metal production and gravitational accretion. They present a widely complementary view with respect to more classical galaxy surveys in the optical.

In a context of ever deeper surveys at most wavelengths, it is even more difficult and important to reliably measure galaxy infrared properties in the Local Universe: difficult because the very possibility to carry out extremely deep observations leads to most observing time being spent on the deepest pencil-beam surveys rather than shallower wider-area ones, and important because the increasingly detailed knowledge of the high-redshift Universe needs similarly well-defined local benchmarks to trace the formation and evolution of galaxies across cosmic time in great detail. Perhaps more importantly, in the era of multi-wavelength surveys and virtual observatories, shallow wide-area surveys with large data rates are likely to profit the most from the paradigm shift caused in astronomical research by the easy access to a number of otherwise separate databases for science exploitation.

Our work capitalizes on the above trends. We present a detailed investigation of statistical properties of infrared galaxies in the low-redshift universe by exploiting two major survey projects, in the infrared and optical respectively. The SWIRE (infrared) and the SDSS (optical) catalogs are matched with early HerMES/Herschel data as well as with ancillary datasets such as the INTWFS, 2MASS and UKIDSS, to derive the galaxy local luminosity function at MIPS (24, 70 and 160μm) and SPIRE (250, 350 and 500μm) bands and thus place stronger constraints on models for the formation and evolution of infrared galaxies.

We first introduce the main properties of the SWIRE-SDSS database, focusing on its multiple applications for galaxy formation and evolution studies over a 50 deg^2 area. We then describe the computation of the local luminosity function and the constraints this sets on phenomenological models of galaxy formation and evolution.

Dust and Gas Cooling in the Nearby Universe: Herschel's KINGFISH

J. D. Smith

KINGFISH is a large Herschel key program targeting a broadly selected sample of nearby galaxies (d<~30Mpc) with 70-500μm photometry and spectral imaging in 5 key cooling lines of the ionized and neutral ISM. When combined with extensive multi-wavelength data sets (e.g. the SINGS and affiliated surveys), KINGFISH is providing a full census of coupled dust emission and gas cooling in all phases of the interstellar medium in galaxies, resolved on sub-kpc scales. I will highlight early and planned KINGFISH science, including warm and cold dust masses, star-formation tracers, the heating and cooling energy budget, temperature insensitive abundances, the resolved radio-IR correlation, and more.

A view from the thermal IR peak: classic galaxies in the Herschel era

M. Sauvage

The Herschel Space Observatory is the first facility that allows a systematic coverage of the complete thermal infrared peak of galaxies, going beyond 200μm, well into the Rayleigh-Jeans regime. This reveals a number of surprising facts and calls for some revision of our conception regarding the interpretation of the far-infrared and submillimeter luminosity of galaxies. In this paper we present a study spiral galaxies as composite objects, namely a star forming disk (occupied by the spiral) and a central region, with the decomposition being done purely with an infrared photometric approach. This shows that galactic disks are remarkably uniform, i.e. their global spectral energy distribution shows little variation from one galaxy to the next, contrary to the central regions that are significantly hotter, and show much more variation from one galaxy to the next. Furthermore, we observe that the central region of galaxies can represent a sizeable fraction of the total luminosity in the shortest wavelength bands of Herschel. We discuss the implication of this composite nature of classic galaxies on the interpretation of the global FIR luminosity (i.e. can it really be interpreted as a star formation tracer, given that it may be more related to the central component).

Mid- and far-infrared spectroscopic diagnostics of local and distant AGNs

E. Sturm

In the past ~5 years the Spitzer Space Observatory has provided a tremendous amount of new mid-IR information in the area of galaxy formation and evolution. Recently the Herschel Space Observatory has begun to complement the picture in the far-IR with impressive and exciting new findings. This talk will highlight some recent spectroscopic results in this field and summarize what can be learned from them about black hole growth, co-evolution of/feed-back between black hole and starbursts, and the quantification of star formation and AGN activity in dusty galaxies.

FIR properties of AGN in the HerMES fields

E. Hatziminaoglou

Nuclear and starburst activity are known to often occur concomitantly. Herschel-SPIRE provides sampling of the FIR SEDs of type 1 and type 2 AGN, allowing for the separation between the hot dust (torus) and cold dust (starburst) emission. One third of the spectroscopically confirmed AGN in the HerMES fields have 5-sigma detections at 250μm. Their combined Spitzer-MIPS and Herschel-SPIRE colors quite clearly separate them from the non-AGN, star-forming galaxy population, as their 24-μm flux is dominated by the hot torus emission. However, their SPIRE colors alone do not differ from those of non-AGN galaxies. SED fitting shows that all those AGN need a starburst component to fully account for their FIR emission. For objects at $z > 2$, there is a weak correlation between the infrared luminosity attributed to the starburst component, L (SB), and the AGN accretion luminosity, L(acc), with L(SB) proportional to $L(acc)^{0.35}$. Type 2 AGN detected at 250μm show on average higher L(SB) than type 1 objects but their number is still too low to establish whether this trend indicates stronger star-formation activity.

Disentangling star formation and active galactic nuclei activity over cosmic time

A. Pope, L. Armus, R.R. Chary, D. Elbaz, K. Dasyra, M. Dickinson

Spitzer mid-infrared spectroscopy has revealed that many high redshift ultra-luminous infrared galaxies (ULIRGs) have much stronger polycyclic aromatic hydrocarbon (PAH) emission than in their local counterparts. This implies that active galactic nuclei (AGN) make a smaller contribution to the bolometric luminosity in high redshift ULIRGs and hints at an evolution in the mid-IR spectrum of IR luminous galaxies with redshift. These suggestive results are based on small subsamples of ULIRGs which suffer strong selection effects. To remedy this, we have assembled a library of ~150 mid-IR spectra of IR luminous galaxies at z>1. This mid-IR spectroscopy is complemented by the deepest images in the X-ray, optical, mid-IR, far-IR (Herschel), submm and radio; together these data allow us to decompose the bolometric luminosity into contributions from star formation and AGN. In this talk I will highlight new results on the Herschel far-IR colors of high redshift IR luminous galaxies as a function of AGN and star formation activity as diagnosed by the mid-IR spectra. Coupled with our knowledge of local galaxies, we can investigate the variation in AGN contribution and PAH emission as a function of redshift, luminosity and galaxy type. An evolution in the dust properties with redshift has significant implications for the application of local empirical star formation rate laws at higher redshift. An understanding of the distribution and variation of PAH emission in high redshift galaxies can help to determine how intense star formation proceeds in the dust obscured galaxies that are orchestrating massive galaxy formation through major mergers or turbulent gas-rich disks.

The Quest for a Complete Census of AGN Activity: Challenges and Progress

D. Alexander

Nearby massive galaxies host massive black holes, which grew through AGN activity. We can trace the growth of these black holes by constructing a complete census of AGN activity across cosmic time. However, constructing this census is challenging due to the presence of large amounts of dust and gas towards the line of site of the majority of the AGNs in the Universe. I will describe the challenges in identifying all AGNs and present our current "best efforts" at constructing a complete census of AGN activity.

A Herschel view on the coevolution of galaxies and AGN

D. Lutz

Herschel has opened a new far-infrared window on SEDs and star formation rates of high redshift galaxies, giving us new handles to unravel mechanisms of galaxy evolution. I will present results from the first year of deep extragalactic surveys in the PEP program, with one focus on the nature and star formation in AGN hosts and the role of secular and merger processes in their evolution.

Absorbed Active Galactic Nuclei Among 70μm-Selected Galaxies

S. Juneau

We present a detailed study of the (co-)occurence of star formation, active galactic nucleus (AGN) activity, and galaxy mergers in a sample of 70μm-selected galaxies from the Far-Infrared Deep Extragalactic Legacy survey (FIDEL). Deep multiwavelength observations reveal a complex connection between starburst, AGN, and dust obscuration. We find that mid-to-far infrared colors, tracing the average dust temperature of the warm grain component, is influenced by the total X-ray luminosity regardless of the source of high-energy photons (starburst or AGN). For galaxies with measurable emission lines, we show that the fraction of 70μm galaxies with any level of AGN activity may be as high as 40-45%, i.e. more common than previously thought. This difference may be due to 70μm galaxies hosting AGNs that are heavily absorbed (Compton-thick). We present evidence that these systems are ideal testbeds for galaxy merger scenarios in which gas-rich galaxies merge, go through a deeply-embedded ULIRG phase before emerging as an X-ray and optically identified AGN. We compile galaxies at different evolutionary stages allowing us to witness this process at redshift ~0.7. Our results suggest that the transition from absorbed to unabsorbed AGN takes place on timescales much shorter than the timescale of either phase. Lastly, we highlight the potential of future IR studies in constraining such evolutionary scenarios.

The Dirt on Dry Mergers

V. Desai

Dry merging (i.e., merging without gas) is invoked in models of hierarchical galaxy formation as an important mode of galaxy assembly, necessary to reproduce the observed fractions and luminosities of galaxies in the red sequence. In one prominent study, van Dokkum (2005), hereafter vD05, found that 70% of nearby (z ~0.1) optically red early-type galaxies show signs of tidal interaction, and concluded that the majority of luminous field ellipticals were formed via dry mergers. We present the long wavelength Spitzer/MIPS (3.6-70μm) SEDs of the vD05 sample. We find that a significant fraction of the dry mergers identified by vD05 are found to have mid-IR emission in excess of what would be expected from a passively evolving galaxy. Based on mid-IR colors, dusty star formation is the likely source of this mid-IR excess. The derived SFRs are large for passive galaxies, with ~25% of the dry merger candidates exhibiting SFRs > 1 M_{Sun}/yr. We will discuss the implications of these results for the relevance of dry merging in the formation of early-type galaxies.

Different star formation modes in distant massive galaxies

E. Daddi

I will present results from our ongoing surveys probing the molecular gas content of distant galaxies with the IRAM Plateau de Bure and VLA interferometers, following our discovery that ordinary near-IR selected galaxies at z>1 are very luminous CO emitters and can be routinely observed and studied already with existing facilities. Star formation modes in the distant Universe can be understood in terms of the spiral/ ULIRG duality that is well characterized locally.

Dynamics and High Cold Gas Fractions in Star Forming Galaxies at z=1-3

L. Tacconi

In an ongoing IRAM two-year Large Program, we are surveying the molecular gas contents and dynamics in two samples of typical massive-star-forming galaxies (SFGs) at redshifts <z> of 1.2 and 2.3. With recent improvements in sensitivity at the PdB Interferometer, we can detect CO line emission from the massive tail of typical, SFGs at these epochs. The full sample comprises ~20 galaxies at each redshift range. The data reveal that SFGs are very gas rich, and that the star formation efficiency is not strongly dependent on cosmic epoch. The average fraction of cold gas relative to total galaxy baryonic mass at z = 2.3 and z = 1.2 is ~ 44% and 34%, respectively, three to ten times higher than in local spiral galaxies. A slow decrease from z~2 and z~1 likely requires semi-continuous replenishment of fresh gas to the young galaxies.

The far-IR - dense molecular gas correlation in galaxies

Y. Gao

High-dipole moment molecules such as HCN and CS trace much denser molecular gas than that of CO which traces the total molecular gas mass. And HCN strongly correlates with the far-infrared (FIR) emission for essential all star-forming systems near and far. CS observations in galaxies further demonstrate similarly tight correlation. Such a tight linear FIR - dense molecular gas correlation demonstrates that the star formation rate depends linearly upon the mass of dense molecular gas and the dense cores might be the basic units of massive star formation in galaxies. The order-of-magnitude increases in both the spatial resolution and sensitivity of the ALMA will reveal many such dense clumps in local galaxies and revolutionize our understanding of the formation of massive stars in galaxies. Yet, large sky area survey/mapping is practically prohibited. Plans and efforts for the Antarctic Dome-A THz telescopes will be briefly mentioned for this purpose.

Multiwavelength properties of Local Luminous and Ultraluminous IR galaxies

A. Karim

In recent years, multi-wavelength surveys carried out in various fields have made it possible to follow the build-up of stellar mass in galaxies and the evolution of their star formation rates (SFRs) over a wide range of redshift. The panchromatic coverage of the 2 deg^2 COSMOS field, in particular, has provided highly accurate measurements of photometric redshifts and stellar masses for an unprecedentedly rich mass-selected sample of galaxies. By stacking into the VLA-COSMOS 1.4 GHz map of the COSMOS field we have determined the average SFR of galaxies as a function of stellar mass. Radio image stacking relies on the dust-unbiased radio continuum emission as a tracer of recent star formation and has the advantage of being less affected by source confusion than stacks in the IR due to the high angular resolution achieved by the VLA.
Using this approach we confirmed the existence of a power-law relation between specific SFR (SSFR) and stellar mass for star forming galaxies out to z=3. While higher mass systems exhibit lower SSFRs at any epoch we do not find any evidence of a differential, more rapid evolution of the SSFR in high mass galaxies; the mass-independent evolution of the SSFR with cosmic time can thus be described by a simple power-law $(1+z)^n$. Together with the observation that the shape of the mass function of star forming galaxies is nearly constant, this universal (S)SFR-mass relation implies that the characteristic mass of galaxies that contribute most to the comoving SFR density does not significantly evolve with cosmic time. We show that the joint evolution of the mass function and the (S)SFR-mass relation can accurately reproduce the cosmic star formation history since z~3.
A central implicit assumption of this work is the validity of the radio-IR relation at all relevant redshifts. By considering Spitzer/MIPS 24 and 70μm data for the same sample of galaxies we were able to show that radio- and IR-based derived SFRs are in good agreement.

Far-Infrared Properties of Submillimeter and Optically Faint Radio Galaxies

B. Magnelli

Since their discovery in the late 1990s, submillimeter galaxies (SMGs) have become the selection of choice for the most luminous tail of the high-redshift star-forming galaxy population. It has been found that SMGs have typical redshift of 2, are compact and massive systems and that the most luminous ones are associated with major mergers. Although SMGs provide a powerful tool to constrain the formation and evolution of massive high-redshift galaxies, their selection is strongly biased, and observational evidence of a missing population of massive high-redshift galaxies with hot dust have been provided by Chapman et al. (2004; OFRGs). While SMGs and OFRGs are an important component of the high-redshift massive galaxy population, many of their fundamental properties still rely on indirect measurements. In particular, their infrared luminosities as well as their dust temperatures are still debated because theoretical simulations have had great difficulty in accounting for their current inferred luminosities/star-formation rates. In this study we use deep PACS observations to obtain, for the first time, robust estimates of the dust temperatures and the infrared luminosities of SMGs and OFRGs.

From the literature we build a sample of 37 SMGs located in the GOODS-N and the A2218 fields. Our OFRG sample is taken from Casey et al. (2009a, 2009b) and contains 10 galaxies all located in the GOODS-N field. These samples are cross-matched with our PACS 100μm and 160μm multi-wavelength catalog builded using an extraction technique based on prior sources positions at shorter wavelength (24um). This multi-wavelength catalog reaches a 3sigma limit of 3 mJy and 5 mJy at 100μm and 160μm in the GOODS-N field while it reaches a 3sigma limit of 2.5 mJy and 4.5 mJy at 100μm and 160μm in the A2218 field. About half the galaxies in our samples are detected in at least one of our two PACS passband. The dust temperatures and the infrared luminosities of our galaxies are derived by fitting their PACS and SCUBA 850μm (only the upper limits for the OFRGs) flux densities with a single modified (β=1.5) blackbody function. Our study confirms that SMGs are biased towards cold dust temperatures (T_{dust}=36±8 K) and that OFRGs are missed by current submm observations because they have hot dust temperatures (T_{dust}=47±3 K). For both samples, dust temperatures derived using Herschel data agree well with previous estimates. In particular, using the same method as Chapman et al. (2005; i.e fitting the submm observations assuming the validity of local FIR/radio correlation), we find dust temperatures in agreement with our estimates. This agreement confirms that the local FIR/radio correlation effectively holds at high redshift even though we find q=2.17±0.19, a slightly lower value than that observed in local systems. Our study also confirms the remarkably large infrared luminosities of SMGs which imply median star-formation rates of 960 M_{sun}/yr for SMGs with S850>5 mJy and of 460 M_{sun}/yr for SMGs with S850>2 mJy. Such high star formation rates are difficult to reconcile with secular evolution (e.g. Davé et al. 2009) and could correspond to a brief, merger driven stage in galaxies evolution (e.g. Tacconi et al. 2008). Finally, we note that for both samples the infrared luminosity estimates from the radio part of the SED are accurate, while estimates from the mid-IR are considerably more uncertain.

Dust grain growth in the interstellar medium of galaxies at redshifts 4<z<6.5

M. Michalowski

The question of the origin of cosmic dust is an important outstanding question of cosmology. I will present the analysis of the dust properties of submillimeter galaxies at redshifts 4<z<5 and quasars at redshifts 5<z<6.5. In particular I will discuss the efficiencies of the stellar dust producers (AGB stars and supernovae) required to explain the huge dust masses present in these high-z galaxies as revealed by far-infrared and (sub)millimeter observations. I will show that AGB stars are definitely not efficient enough to form dust in some of these galaxies and that supernovae could in principle be responsible for the dust production, but with very high required dust yield per one supernova. I will present the evidences that the dust grain growth in the interstellar medium of these galaxies is required to explain their dust masses.

Towards a complete census of high-z ULIRGs with Herschel

G. Magdis

Although local ULIRGs contribute a very small fraction of the IR luminosity density, their cosmological importance increases with increasing redshift. Many of their fundamental properties though, still rely on indirect measurements, while there is evidence that methods of detecting high-z ULIRGs are strongly affected by selection biases.

I will present a detailed study of the far-IR properties of a sample of mid-IR selected z~2 star-forming dominated ULIRGs, based on Herschel PACS and SPIRE as part of the HERMES project. I will discuss how Herschel observations:

- provide the means for a T_d-unbiased study of high-z ULIRGs,

- reveal a wide range of dust temperatures, suggesting a diversity of the physical mechanisms that trigger star-formation on the early universe,

- demonstrate that a large fraction of high-z ULIRGs are missed by current ground based (sub)mm surveys.

I will then extend to z~3, considering a sample of ULIRG Infrared Luminous Lyman Break Galaxies. I will first present a multi-wavelength view of the star-formation activity at z~3 and put constraints on the SFR of LBGs. Based on the large SFR of some LBGs though, it is somewhat surprising that there are only few examples of direct submillimeter detection for these galaxies, indicating that the far-IR properties are still unclear.

Using PACS observations of GOODS-N as part of the PEP project, I will then present first insights into the far-IR properties for a sample of z~3 LBGs:

- Construct for the first time, the average SED of infrared luminous LBGs from UV to radio wavelengths,

- Put constraints on the dust temperature of the population showing that LBGs are warmer than SMGs and observe for the first time the general LIR-Td trend seen in the local universe, for UV-selected galaxies at z~3,

- Shed light on the marginal detection of LBGs in current sub-mm surveys.

The Broad Hint for dust extinction of star-forming galaxies at z>4

H. Shim

We present the rest-frame optical star formation rates of z~4 galaxies selected over the Great Observatories Origins Deep Survey (GOODS) fields. Without selection biases for colors, more than 70% of the galaxies with spectroscopic redshifts at 3.8<z<5.0 show excess in Spitzer IRAC 3.6μm band compared to the expected flux using stellar continuum only. We suggest that this 3.6um excess is due to the redshift Hα emission line in these galaxies, reflecting their high star formation rates. These Hα emitter (HAE) candidates at z~4 have star formation rates of 20-500 M_{sun}/yr, with large Hα equivalent width of >350A. The ratio between Hα line flux and the UV continuum flux is well-correlated with the UV slope β. Thus the Hα line-to-UV continuum ratio works as an alternative measure of dust extinction for high-redshift star-forming galaxies, providing strong constraints on the dust properties of high-redshift star-forming galaxies. The Herschel PACS/SPIRE photometry of these galaxies would be another strong constraints for verifying the use of emission line-to-UV continuum indicator for dust extinction.

Do submillimeter galaxy number counts provide evidence for an evolving IMF?

C. Hayward

Matching the observed abundance and redshift distribution of submillimeter galaxies (SMGs), some of the most luminous, rapidly star-forming galaxies in the Universe, has been a notorious problem for galaxy formation models. Typically, solutions to this problem have required ad hoc IMF variations at high redshift, ranging from a "bottom-light" IMF (Dave et al. 2009) to the extreme "flat" IMF (Baugh et al. 2005). I will argue that significant IMF modifications are not justified by the apparent conflict between observed SMG number counts and those predicted by previous models. I will present a multi-scale model for the formation of SMGs which can accurately reproduce the observed UV-mm wave SED, inferred physical properties, and observed number counts of this population. Our model, the first to combine high-resolution N-body/ hydrodynamic simulations and dust radiative transfer in a cosmological framework, is able to match observed 850μm number counts even while utilizing a "standard" Kroupa IMF.

Evolution of galaxies in the IR in CDM galaxy formation models

C. Lacey, C. Baugh, C. Frenk

I present theoretical predictions for the evolution of galaxies at IR wavelengths, obtained from a CDM-based model of galaxy formation combined with a detailed model for the reprocessing of stellar radiation by dust. The predictions include IR luminosity functions at different redshifts, number counts and redshift distributions, lumininosities at other wavelengths (from the UV to radio), and also galaxy clustering at different redshifts. I compare these predictions with results from Spitzer and Herschel. In our previous work on modelling sub-mm galaxies, we found that a top-heavy IMF in starbursts seemed to be needed to reproduce the observed 850μm counts, and the evolution of the 24μm luminosity function found in Spitzer surveys seemed to support this. I will examine whether this model is consistent with the new data from Herschel. I will also describe work we are doing on incorporating black hole growth and AGN feedback into our model, to try to arrive at a unified model of galaxy and AGN evolution.

Ultraviolet-to-infrared SED modelling of local (U)LIRGs

E. da Cunha, V. Charmandaris, S. Charlot, D. Elbaz, T. Díaz-Santos, L. Armus

We present a simple, angle-averaged model that allows one to interpret the infrared emission of galaxies consistently with the ultraviolet and optical emission. Particular features of our model include the dust heating by both young and old stellar populations in galaxies, and the consistent balance between the energy absorbed and re-emitted by dust. Using this model, we derive statistical constraints on several parameters related to the star formation activity and dust content of large samples of local star-forming galaxies spanning a wide range in total infrared luminosity. We present a recent application of this model to the interpretation of local, purely star-forming ultraluminous infrared galaxies (ULIRGs). We place our results in context of similar studies of lower luminosity systems and show how our spectral modelling can be used to investigate the star formation mode of galaxies. Finally, we introduce an ongoing extension of our model to the interpretation of the spectral energy distributions of galaxies with non-negligible AGN contribution to the total infrared luminosity from the Great Observatories All-sky LIRG Survey (GOALS).

Modelling the spectral energy distribution of galaxies

C. Popescu

We present a self-consistent model of the spectral energy distributions (SEDs) of spiral galaxies from the ultraviolet (UV) to the mid-infrared (MIR)/far-infrared (FIR)/submillimeter (submm) based on a full radiative transfer calculation of the propagation of starlight in galaxy disks. This model predicts not only the total integrated energy absorbed in the UV/optical and re-emitted in the infrared/submm (energy balance), but also the colours of the dust emission based on an explicit calculation of the strength and colour of the radiation fields heating the dust, also incorporating a full treatment of the stochastic heating of small dust grains and PAH molecules. The colour information from the IR/submm is used to self-consistently constrain the relative attenuation of light coming from stellar populations of different ages.
The results of the calculations are presented in the form of a large library of simulated dust emission SEDs spanning the whole parameter space of our model, which, together with a corresponding library of dust attenuation can be used to routinely fit the observed SEDs of spiral galaxies coming from large statistical samples of panchromatic data. We thus combine the predictive power of radiative transfer calculations with the efficiency of a fast optimisation fitting routine to circumvent the need for lengthy calculations on individual objects, which have hitherto prevented such analysis to be done for more than a handful of galaxies.

AGN dust model of high redshift 3CR sources

R. Siebenmorgen, F. Heyman, M. Haas

This talk provides high angular resolution mid IR observation of local galaxies with VISIR at the VLT, detections of the most powerful high redshift Active Galactic Nuclei (AGN) with Spitzer, namely the complete 3CR sample at redshift $z > 1$, and a new dust radiative transfer model of the measured AGN spectral energy distribution in the infrared. The VLT data enables us to distinguish the activity type of nearby galaxies which is of great potential using future telescope projects such as the E-ELT 42m. The orientation dependence of the NIR and MIR emission is discussed by the Spitzer results which confirm the unification scheme for the most powerful high redshift AGNs. A newly developed method to solve the radiative transfer equation in three dimensional configurations is presented. The method takes full advantage of the parallelization capabilities of modern vector computing units. In combination with an update of our ISM dust model we present the close environment of the AGN in a clumpy three dimensional dust torus geometry.

Unveiling the Cosmic Infrared and Submillimeter Backgrounds

H. Dole

The Extragalactic Background Light, relic emission of all post-recombination processes, i.e. mainly star formation and accretion, tells us about structure formation and evolution. I will review the current measurements on the infrared and submillimeter part of the background (including recent results from Herschel): direct detections, lower limits, upper limits, confidence, as well as other means to investigate the extragalactic background, like the fluctuation analysis. Finally, I will discuss the implications of those measurements, in combination with results from surveys and models.

Lessons Learned from BLAST

M. Viero

Observing at 250, 350 and 500μm for 11 days, the Balloon Borne Large Aperture Submillimeter Telescope (BLAST) was a pathfinder for the SPIRE instrument on the Herschel space observatory. BLAST opened a new window towards the understanding of infrared astrophysics by making maps of unprecedented size and depth at these wavelengths. Although those maps have since been eclipsed by Herschel, BLAST's legacy lives on in the lessons learned and communicated to the astrophysical community regarding the analysis of highly confused maps to extract as much information as possible; lessons which remain relevant for analyzing the flood of confusion-limited data arriving daily. Here I will give a brief overview of the BLAST results, the techniques developed or used by BLAST, and a justification for their uses.

Extragalactic Astrophysics with the Wide-field Infrared Survey Explorer

P. Eisenhardt

NASA's Wide-field Infrared Survey Explorer (WISE) launched on 2009 Dec. 14, and began its all-sky survey one month later. The scientific objectives of the survey range from identifying the nearest brown dwarfs to the Sun to the most luminous galaxies in the Universe. By July WISE will have imaged the entire sky at 3.4, 4.6, 12, and 22μm, and will continue to do so until the cryogen is exhausted in October or November 2010. The preliminary data release will occur 6 months after the end of the survey, and the final data release will be 17 months after the survey. The final source catalog will contain hundreds of millions of objects. WISE 5σ point source sensitivity is approximately 0.08, 0.1, 1, and 5 mJy in the four IR bands, and the spatial resolution is 6 arcsec FWHM (12 arcsec at 22μm). I will present some initial extragalactic results from WISE, ranging from local compact star-forming galaxies to hyper-luminous IR galaxies at $z > 2$.

Challenges with SPICA

H. Matsuhara on behalf of the SPICA Team & Science Working Group

SPICA (Space Infrared Telescope for Cosmology and Astrophysics) is a space observatory that will provide imaging and spectroscopic capabilities in the 5 to 210μm wavelength range with 3-m class telescope like Herschel, but with unprecedented sensitivity thanks to the cold telescope (<6 K) and advanced instrument suite. To reduce the mass of the whole mission, SPICA will be launched at ambient temperature and cooled down on orbit by mechanical coolers on board with an efficient radiative cooling system, a combination of which allows us to have such a large, cooled telescope in space with moderate total weight (3.7t). SPICA is a Japanese-led, international mission with significant contribution from ESA and a European consortium, and Korea. US participations is also being discussed extensively. The target launch year of SPICA is FY2018. SPICA will be between one and two orders of magnitude more sensitive than Herschel in the far infrared spectroscopy, and a few orders of magnitude faster in the imaging surveys. The US participation will provide us with a far better spectroscopic sensitivity. SPICA will also cover the missing 28 to 55μm wavelength which is out of the Herschel and JWST domains. With SPICA we will challenge to address a number of key problems in present-day astronomy, ranging from the star-formation history of the universe to the formation of planets. Namely, SPICA will be able to carry out blind spectroscopic surveys out to z~3, which will lead to the first statistically unbiased determination of the co-evolution of star formation and mass accretion with cosmic time.

MIR/FIR Spectroscopy of AGN and starburst along galaxy evolution with SPICA-SAFARI

L. Spinoglio

MIR/FIR spectroscopy with the SAFARI FTS onboard of the future mission SPICA will allow for the first time to perform spectroscopic cosmological surveys in the rest frame mid- to far-infrared. This will permit to obtain directly, in a "single shot" redshifts, and therefore luminosities, and the intrinsic nature of the objects, i.e. if starburst or AGN dominated. Computations based on the observed mid to far-IR luminosity functions and backward evolution models show that in a single field of view of SAFARI (2x2 arcmin^2) we will be able to detect and classify on average 10 objects of redshift z=0.1-3 in 1 hour integration. This will allow for the first time deep spectroscopic cosmological surveys of the intermediate redshift Universe at wavelengths which do not suffer heavy obscuration and where the peak energy is emitted.

Abstracts – Posters

P1. Green Valley Galaxies: Extincted Starbursts or Evolving Post Starburst?

H. Aussel

The Green Valley (GV) is the region of transition between the Blue Cloud (BC) and the Red Sequence (RS), the two prominent features of the UV–Optical color-magnitude diagram of galaxies (Wyder et al., 2007). Galaxies populating this region are possibly transiting toward the red sequence and are important to understand the build-up of the population of ellipticals observed today. Various evolutionary scenarii have been proposed to explain how the present day massive red galaxies are formed (Faber et al., 2007). One main route is based on dry mergers of small red elliptical (e.g. Bell et al. 2006), the other on the build up of star forming galaxies, and their subsequent passive evolution onto the red sequence (Noeske et al. 2007). This latter route predict an important flux of galaxies through the Green Valley. This flux seems to have been detected by Martin et al. (2007). However, the Martin et al. (2007) result is questioned by Brammer et al. (2009) that show that a significant fraction of Green Valley galaxies belong in fact to the Blue Cloud, and have been scattered outside by dust extinction. These galaxies are recognized as actively star forming thanks to their mid- infrared flux (MIPS 24μm), and the extinction correction derived from the UV-optical data alone seem inadequate to correct the colors. Recently, Kelson & Holden (2010) have claimed that the strong mid-IR emission of GV galaxies could be due to TP-AGB stars instead of dust from star forming regions. Indeed, such stars are expected to dominate the NIR and MIR emission of a single population about 1 Gyr after the episode of star formation (Maraston, 1996) and could well be important for Green Valley galaxies. This would invalidate Brammer et al. (2009) conclusions, and make of all GV galaxies true post-starbursts. Herschel data provide us with an opportunity to close the debate once for all. We have selected a sample of GV galaxies in the COSMOS field between z=0.3 and 1.4, identify the ones that have a Spitzer 24μm emission and checked whether these are detected with PACS at 100 and 160 μm. Since the dust of TP–AGB is much warmer than the one of star forming regions, we are able to determine whether the 24 μm emission is indeed due to star formation, and settle on the true fraction of transiting galaxies between the Blue Cloud and the Red Sequence.

P2. Far-Infrared Line Imaging of the Starburst Ring in NGC1097

P. Beirão

NGC 1097 is a nearby SBb galaxy with a Seyfert nucleus and a bright starburst ring. We study the physical properties of the interstellar medium (ISM) in the ring using spatially resolved far-infrared spectral maps of the circumnuclear starburst ring of NGC 1097, obtained with the PACS spectrometer on board the Herschel Space Telescope. In particular, we map the important ISM cooling and diagnostic emission lines of [OI] 63μm, [OIII] 88μm, [NII] 122μm, [CII] 158μm and [NII] 205μm. We observe that in the [OI] 63μm, [OIII] 88μm, and [NII] 122μm line maps, the emission is enhanced in clumps along the NE part of the ring. We

observe evidence of rapid rotation in the circumnuclear ring, with a rotation velocity of ~220 km/s (inclination uncorrected) measured in all lines.
The [OI] 63μm/[CII] 158μm ratio varies smoothly throughout the central region, and is enhanced on the northeastern part of the ring, which may indicate a stronger radiation field. This enhancement coincides with peaks in the [OI] 63μm and [OIII] 88μm maps. Variations of the [NII] 122um/[NII] 205μm ratio correspond to a range in the ionized gas density between 150 and 400 cm^{-3}.

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P3. Infrared properties of compact groups of galaxies. How the environment affects galaxy evolution.

T. Bitsakis, V. Charmandaris, E. da Cunha, E. Le Floc'h, T. Díaz-Santos

Hickson compact groups (HCGs) are among the densest galaxy environments of the local universe. To examine the effects of the environment on the infrared properties of these systems, we present a multi-wavelength, from UV to far-IR, analysis of 32 HCGs containing 135 galaxies. Based on mid-infrared color diagnostics we identify the galaxies that appear to host an active nucleus. Using a fitting code developed by E. da Cunha, we fit the complete infrared spectral energy distribution for each group member and derive the main physical parameters of these galaxies. We compare our estimates of galaxy mass, star formation rate, total infrared luminosities, and specific star formation rates (sSFR) for our HCG sample to samples of isolated galaxies and interacting pairs and find that overall there is no discernible difference among them. However, HCGs that can be considered as dynamically "old" host late-type galaxies with a slightly lower sSFR than the one found in dynamically "young" groups. This could be attributed to multiple past interactions among the galaxies in old groups, that have led to the build up of their stellar mass. It is also consistent with our prediction of the presence of diffuse cold dust in the intergalactic medium in several of the dynamically "old" groups.

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P4. Spatially Resolved PAH Emission Features in Nearby Star-Forming Galaxies

J. M. Cannon, K. Haynes, E. D. Skillman, R. D. Gehrz, D. C. Jackson

Low-resolution, mid-infrared Spitzer IRS spectral maps are presented for three nearby, low-metallicity dwarf galaxies (NGC55, NGC3109 and IC5152) for the purpose of examining the spatial distribution and variation of polycyclic aromatic hydrocarbon (PAH) emission. The sample straddles a metallicity of 12 + log

(O/H) ~ 8, a transition point below which PAH emission strength empirically drops and the character of the interstellar medium changes. We derive quantitative strengths and flux values for PAH features and atomic lines on both global and spatially-resolved scales. The Spitzer spectra, combined with extensive ancillary data providing the strengths of emission from warm dust and ionized gas, allow us to examine changes in the physical environments and in PAH feature strengths down to a physical scale of ~50 pc. We discuss correlations between various PAH emission feature and atomic line fluxes. The 6.2μm/11.3μm, 7.7μm/ 11.3μm, 8.6μm/11.3μm, 7.7μm/6.2μm, and 8.6μm/6.2μm PAH line strength ratios are found to be independent of position across all three galaxies, although the ratios do vary from galaxy to galaxy. Absolute PAH feature strengths as measured by a ratio of PAH/24μm line emission are seen to vary both positionally within a given galaxy, and from one galaxy to the next when integrated over the full observed extent of each system. We also examine direct comparisons of CC mode PAH ratios 7.7μm/6.2μm and 8.6μm/6.2μm to the mixed (CC/CH) mode PAH ratio 7.7μm/11.3μm. We find little variation in either mode, and no difference in trends between modes. While the local conditions change markedly over the observed regions of these galaxies, the properties of PAH emission show a remarkable degree of uniformity.

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P5. Powerful H_2 Line Cooling in Stephan's Quintet and other probes of Compact Group Evolution

M. Cluver

Stephans Quintet (SQ) is a strongly interacting compact group experiencing a group-wide shock (~30 kpc) due to the high velocity (~1000 km/s) collision of an intruder galaxy with the intragroup medium. I will show recent results from deep, mid-infrared spectral mapping of SQ, using the Spitzer Space Telescope, that reveal for the first time the striking abundance and widespread distribution of warm molecular hydrogen emission within the group, with the H_2 emission dominating the cooling from X-ray emission. Emission line diagnostics and star formation tracers in the group, and their significance, will also be discussed.
The SQ system is one group in a sample of 24 Hickson Compact Groups chosen to be violently interacting and in a state of active transformation. The process whereby compact groups merge to form massive galaxies is fundamental to our understanding of galaxy formation via essentially "dry" mergers. The interplay between the stripped intragroup medium and the transforming galaxies at intermediate stages of this process remains poorly understood. I will discuss the mid-infrared properties and diagnostics (particularly spectroscopic) being used to probe this phase of compact group evolution.

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P6. Unveiling Far-Infrared Counterparts of Bright Submillimeter Galaxies Using PACS Imaging

H. Dannerbauer

Several hundred dust-enshrouded high-z sources have been selected through submm/mm imaging with bolometer cameras like SCUBA, LABOCA, AzTEC and MAMBO. The identification of counterparts of these so-called Submillimeter Galaxies (SMGs) is mainly based on radio observations, yielding an identification rate of 50-80%. The launch of the Herschel observatory promises a new view on these dust-obscured, massive star-forming galaxies. Herschel imaging samples the FIR emission of these dust-enshrouded high-z objects and enables us to study in detail their far-infrared spectral energy distribution, redshift distribution, dust temperatures and dust masses. I will present results of our search for Herschel-PACS counterparts of bright Submillimeter Galaxies in the GOODS North region, using deep Herschel-PACS imaging at 100 and 160μm from the PEP survey.

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P7. Spatially resolved (U)LIRGS in GOALS

T. Díaz-Santos

We present an analysis of the extended mid-infrared (MIR) emission of the Great Observatories All-Sky LIRG Survey (GOALS) sample based on 5-15μm low resolution spectra obtained with the Infrared Spectrograph on Spitzer. We calculate the fraction of extended emission as a function of wavelength for the galaxies in the sample, FEE_{λ}, defined as the fraction of the emission which originates outside of the unresolved component of a source at a given distance. We find that the FEE_{λ} varies from one galaxy to another, but we can identify three general types of FEE_{λ}: one where FEE_{λ} is constant, one where features due to emission lines and polycyclic aromatic hydrocarbons (PAH) appear more extended than the continuum, and a third which is characteristic of sources with deep silicate absorption at 9.7um. More than 30% of the galaxies have a median FEE_{λ} larger than 0.5, implying that at least half of their MIR emission is extended. Luminous Infrared Galaxies (LIRGs) display a wide range of FEE in their warm dust continuum ($0<\sim FEE_{13.2\mu m}<\sim 0.85$). The large values of $FEE_{13.2\mu m}$ that we find in many LIRGs suggest that the extended component of their MIR continuum emission originates in scales up to 10kpc, and may contribute as much as the nuclear region to their total MIR luminosity. The mean size of the LIRG cores at 13.2μm is 2.6kpc. However, once the IR luminosity of the systems reaches the threshold of $LIR\sim 10^{11.8} L_{sun}$, slightly below the regime of Ultra-luminous Infrared Galaxies (ULIRGs), all sources become clearly more compact, with $FEE_{13.2\mu m}<\sim 0.2$, and their cores are unresolved. Our estimated upper limit for the core size of ULIRGs is less than 1.5kpc. Furthermore, our analysis indicates that the compactness of systems with $LIR>\sim 10^{11.25} L_{sun}$ strongly increases in those classified as mergers in their final stage of interaction. The $FEE_{13.2\mu m}$ is also related to the contribution of an active galactic nucleus (AGN) to the MIR emission. Galaxies which are more AGN-dominated are less extended, independently of their LIR. We finally find that the extent of the MIR continuum emission is correlated with the far-IR IRAS $\log(f_{60um}/f_{100um})$ color. This enables us to place a

lower limit to the area in a galaxy from where the cold dust emission may originate, a prediction which can be tested soon with the Herschel Space Telescope.

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P8. Searching for the oldest and most massive galaxies at high z

H. Dominguez-Sanchez

We will present the evolution of galaxy mass assembly and star formation as a function of z. We consider a sample of galaxies in the crucial redshift range 1.4<z<3. We select the oldest and most massive galaxies at high z in the COSMOS field by using multiwavelength data from different surveys. In particular, we are interested in very red objects selected in the NIR/MIR bands with very faint optical counterparts. Our catalogue is IRAC (3.6μm) selected.We cross-correlate the IRAC bands with the optical and MIPS catalogues. For sources with no optical counterpart we cross-correlate the IRAC bands with a K-selected catalogue. There is also an important number of sources with only IRAC detection.
We determine the redshift and physical parameters (mass, age) of each source through a detailed SED-fitting analysis and comparison with known template libraries. Based on the SED-fitting classification we select our sample of passive massive galaxies at high redshift (z>1.4) and study its evolution to compare our results with those from semianalytical models.
As a complementary work we make use of the recent Herschel PACS data at 100 and 160μm to measure of the IR Luminosity [8-1000 μm] of high redshift galaxies, that we convert into SFR . We study the evolution of the SSFR(SFR/mass) with z, to try to understand the link between SFR and mass at high redshift galaxies.
We find that the optically obscured objects provide an important contribution to the massive-end of the high-z stellar mass function. We also find that the SSFR decreases with mass in all redshift bins and that more massive galaxies have the lowest SSFR at any z, implying that they have formed their stars earlier and more rapidly than their low mass counterparts, both of our results in agreement with the downsizing scenario.

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P9. Ionized regions in ULIRGs: Dust-bounded, obscured, or partially covered outflowing structures

J. Fischer

The first Herschel fine-structure line observations of ULIRGs are revealing both kinematic and ionization characteristics that may help to explain the significant and enigmatic emission line deficits in these galaxies.

The line-to-infrared luminosities are deficient compared with lower luminosity galaxies and the dependence of these deficits on line wavelengths, ionization potentials, and critical densities can differentiate between high dust opacities, high ionization parameters and high densities. New Herschel observations of massive molecular outflows in ULIRGs, what may drive them, and what these observations tell us about the ULIRG evolutionary phase are also discussed.

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P10. Herschel Virgo Cluster Survey

J. Fritz

The Virgo cluster provides us with a unique opportunity to study in detail a large number of galaxies in the cluster environment. Virgo is probably the most studied cluster of galaxies because of its proximity to the Milky Way - it lies at a distance of 17 Mpc, with a mean velocity of 1064 km/s. It is an Abell richness Class I cluster containing 2000 optically catalogued galaxies. The "HeViCS" is an approved Herschel Open Time Key Project for which 286 hours of parallel mode observing time has been awarded, that will map a considerable portion of the Virgo Cluster in five bands (PACS 100, 160 and SPIRE 250, 350 and 500μm).
These observations will be obtained from the ESA Herschel Space Observatory, in particular employing Herschel's large telescope and powerful science payload to do photometry using the PACS and SPIRE instruments. We will observe four 44 sq deg regions of the cluster down to the 250μm confusion limit of 1 MJy/sr. The primary HeViCS science goals include: the detection of dust in the inter-galactic medium, the extent of cold dust in the outskirts of galaxies, the FIR LFs, the complete SEDs of galaxies, the dust content of dwarf elliptical and irregulars and a detailed analysis of the dust content of early type galaxies.
The Science Demonstration Phase field that was observed in Nov. 2009, already allowed us to achieve impressive results, such as the first observations of truncated dust discs due to the cluster environment, the first convincing detection of dE galaxies in the IR (apart from Andromeda's satellites), the resolved dust surface density and temperature maps of galaxies and to confirm the non-thermal origin of IR emission in M87.

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P11. Herschel observations of water vapour in Markarian 231

E. González-Alfonso

The Ultra luminous infrared galaxy (ULIRG) Mrk 231 reveals up to seven rotational lines of water (H_2O) in emission, including a very high-lying (E_{upper} = 640 K) line detected at a 4σ level, within the Herschel/SPIRE

wavelength range (190μm < λ < 640μm), whereas PACS observations show one H_2O line at 78μm in absorption, as found for other H_2O lines previously detected by ISO. The absorption/emission dichotomy is caused by the pumping of the rotational levels by far-infrared radiation emitted by dust, and subsequent relaxation through lines at longer wavelengths, which allows us to estimate both the column density of H_2O and the general characteristics of the underlying far-infrared continuum source. Radiative transfer models including excitation through both absorption of far-infrared radiation emitted by dust and collisions are used to calculate the equilibrium level populations of H_2O and the corresponding line fluxes. The highest-lying H_2O lines detected in emission, with levels at 300-640 K above the ground state, indicate that the source of far-infrared radiation responsible for the pumping is compact (radius = 110-180 pc) and warm (T_{dust} = 85-95 K), accounting for at least 45% of the bolometric luminosity. The high column density, $N(H_2O) \sim 5\times10^{17}$ cm^{-2}, found in this nuclear component, is most probably the consequence of shocks/cosmic rays, an XDR chemistry, and/or an "undepleted chemistry" where grain mantles are evaporated. A more extended region, presumably the inner region of the 1-kpc disk observed in other molecular species, could contribute to the flux observed in low-lying H_2O lines through dense hot cores, and/or shocks. The H_2O 78μm line observed with PACS shows hints of a blue-shifted wing seen in absorption, possibly indicating the occurrence of H_2O in the prominent outflow detected in OH (Fischer et al. 2010, A&A, 518, L41). Additional PACS/HIFI observations of H_2O lines are required to constrain the kinematics of the nuclear component, as well as the distribution of H_2O relative to the warm dust.

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P12. Using nearby Star-forming regions to understand far: The case of 30 Doradus

B. Groves

30 Doradus, due to its proximity and location in the LMC, provides one of the best opportunities for understanding extreme star-formation events. The low metallicity and high SFR of 30 Doradus make it a possible representative of the star formation that occurs at higher redshift. I will present here recent analysis of the mid-IR spectrum of 30 Doradus, demonstrating what information can be extracted from this region, and the limits on this.

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P13. High redshift (z=1.5) galaxy clusters

M. Haas

While thousands of galaxy clusters are known in the local universe, beyond redshift z=1 cluster knowledge rapidly decreases. In order to test the decline of cluster space density at z>1 predicted by growth-of-structure models, we take advantage of radio sources as signposts for cosmic mass peaks and study the galaxy clustering around massive radio sources. Observations of the z=1.5 quasar 3C270.1 with the Spitzer Space Telescope at 3.6-24μm and with the 6.5-m MMT in the z'-band allow detection of potential cluster members via photometric redshifts. Compared with nearby control fields, there is an excess of extremely red objects (EROs) consistent with a proto-cluster around the quasar. The spectral energy distributions of 3/4 of the EROs are better fitted with passive elliptical galaxies than with dust-reddened starbursts, and of four sources well-detected on an archival HST snapshot image, all have undisturbed morphologies. This pilot study demonstrates that the Spitzer/IRAC maps provide an efficient way to search for clustering of red galaxies around high redshift radio sources, but accurate redshifts and the nature of the galaxies have to be confirmed with additional spectroscopy and/or deep far-infrared imaging with the Herschel Space Observatory. The ongoing investigation of all 64 high-redshift 3CR sources will result in a homogeneous database of considerable cosmological impact. (Haas et al. 2009, ApJ 695, 724)

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P14. An atlas of mid-IR spectra of active galaxies; silicates in AGN and model implications

A. Hernán-Caballero, E. Hatziminaoglou

We present a sample of ~700 archival Spitzer/IRS spectra of star-forming and active galaxies, spanning a wide range of physical properties and including low, intermediate and high redshift sources up to z~3. Ancillary data in the optical, X-Rays, and near- and mid-IR is also provided for many of the sources. In a subsample of 258 AGN-dominated sources spanning the redshift range between 0.01 and 1.8, we are conducting a concise study of their MIR spectral features. The distribution of streght, peak restframe wavelength and luminosity of the 10 and 18μm silicate features is analyzed, as well as the the correlation with other spectral properties such as optical classification and IR continuum slope, with a discussion on the implications for models of the AGN dust torus.

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P15. PDRs in blue compact dwarf galaxies: the Herschel era

V. Lebouteiller, S. Madden, D. Cormier, F. Galliano, S. Hony, M. Galametz

While recent infrared and submm observatories have revolutionized our understanding of the interplay between massive star formation and the ISM, paradoxically still little is known about blue compact dwarf

galaxies (BCDs). The low abundance of dust and molecules in these objects hampers detailed analysis of the parameters associated to star-formation. Herschel is now opening new perspectives with the detection of cold dust, and with the detection of lines arising in photodissociation regions in many BCDs. I will present some early results on the Dwarf Galaxy Survey (PI: S. Madden).

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P16. 2D kinematics and physical properties of distant galaxies

M. Lemoine-Busserole, F. Lamareille, A. Bunker, M. Kissler-Patia

The study of the physical properties of high-redshift galaxies has become one of the major goals of extragalactic astronomy. In particular the mass-assembly histories of galaxies have been the focus of many studies at redshift 1 to 3. We will present recently published results obtained from Integral Field NIR Spectroscopy of a sample of 13 high-z (1<z<4) star-forming galaxies (4<230 M_{sun}/yr). We spatially resolved the kinematics using bright rest-frame optical emission lines, allowing studies of dynamical masses, SFRs, Tully-Fisher relations and metallicities at these "key" epochs. Using this data, we can set constrains on the formation and evolution of this galaxies, during an epoch of when we expect strong evolution in their masses and mass-to-light ratios. We found in particular relatively young stellar populations (<1.5 Gyr) in our objects and most of them have not yet converted the majority of their gas into stars (gas fraction>50%). Finally we show that those of them which already have a stable disc will probably have their final stellar mass similar to the present-day spirals, to which these rotating systems can be seen as precursors.
We will briefly present also an interesting result obtained for a comparable star-forming "clumpy" galaxy (A370-A5, z=1.341) discovered as an arc behind the lens cluster Abell 370 (z=0.374). The natural magnification due to massive galaxy clusters allows to spatially resolve and constrain the dynamics of young star forming galaxies 1 to 3 magnitudes fainter than those selected in blank fields. Thus, the study of lensed galaxies allows to probe a low mass regime of galaxies not accessible in standard observation. In this particular case, we found that the gas distribution and kinematics are consistent with a bipolar outflow with a range of velocities of v~100 km/s.

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P17. K-corrections in optical and near-infrared

A.-L. Melchior, I. Chiligarian, I. Zolotukhin

Relying on a 10^5 galaxy sample constructed using the Virtual Observatory from SDSS DR7 and UKDISS DR5 photometry, we study the k-corrections for galaxies with z<0.5. We demonstrate that k-corrections can be precisely approximated as two-dimensional low-order polynomials of only two parameters: redshift and one observed colour. We validate the procedure in g and r with a direct computation of the k-correction from SDSS DR7 spectra. We find a good agreement between our fitting based on PEGASE.2 and the KCORRECT procedure.

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P18. Using Adaptive Optics to study (U)LIRG Mergers in the Nearby Universe

A. Medling & C. Max

We present near-infrared integral field spectroscopy of nearby gas-rich galaxy mergers. We use laser guide star adaptive optics to resolve the nuclear regions of these systems. These mergers, largely (U)LIRGs, are bright in the infrared due to a combination of starburst and AGN activity. Many of our targets have also been observed as part of the GOALS survey, which adds HST, Spitzer, Galex and Chandra data for these systems. We discuss some of the things we can learn about these transition objects, including black hole mass estimate techniques and a discussion of evolution along the M-sigma relation. We also discuss the contributions that future adaptive optics systems on large ground-based telescopes are expected to make to this field.

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P19. Testing the unification model for AGN in the infrared: are the obscuring tori of Type 1 and 2 AGN different

C. Ramos Almeida, N. A. Levenson, J. M. Rodríguez Espinosa, A. Alonso-Herrero, A. Asensio Ramos, J. T. Radomski, C. Packham, R. S. Fisher, C. Telesco

In a recent work (Ramos Almeida et al. 2009), we presented ground-based subarcsecond resolution mid-IR photometry (8 to 20μm) of eighteen Seyfert galaxies obtained primarily with the Gemini Telescopes. This is one of the largest compilations of mid-IR observations of Seyferts (Sy) at this resolution. We constructed spectral energy distributions (SEDs) with the unresolved mid-IR fluxes which are dominated by the AGN emission, and augmented the data with near-IR measurements from the literature at similar angular resolution. We fitted the SEDs with the clumpy torus models of Nenkova et al. (2008), which accurately reproduce the high spatial resolution measurements. In the models, the outer radial extent of the torus scales with the AGN luminosity, and we find the tori to be confined to scales less than 5 pc. The sample emphasizes

obscured AGN, and thus contains a larger number of Sy2 than Sy1. Our modeling of the SEDs suggests different torus parameters for Type-1 and 2 AGN, which would imply that their tori are intrinsically different. We have recently enlarged the sample with new T-ReCS/Gemini observations of Sy1, which allows a proper comparison of the detailed parameters of Sy1 and Sy2 nuclei. Our preliminary results confirm that in fact, Sy1 tori are thinner and contain fewer clouds than those of Sy2, implying that the differences between Type-1 and 2 AGN are not only due to orientation effects, but also to different covering factors in their tori.

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P20. Coeval Star Formation and Black Hole Growth in the Most Massive Galaxies

J. Rawlings

High redshift radio galaxies (HzRGs) are known to be among the most massive galaxies in the Universe and host a powerful radio-luminous active galactic nuclei (AGN) at their center. Using mid infra-red (IR) spectra obtained from the Infra-Red Spectrometer (IRS) instrument on-board Spitzer, we aim to observe evidence of rapid star-formation inside these galaxies to compare the relative contribution of AGN activity and star formation to their bolometric output. We will measure the rate of this star-formation by observing spectral features such as polycyclic aromatic hydrocarbon emission (PAHs) and also measure the silicate absorption. We shall also determine the power of the AGN from their rest-frame IR luminosities. This work we enable us to better understand the connection between AGN and star-formation activity by measuring the coeval growth of the black hole and host galaxy in these distant rare sources.

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P21. The far-infrared/submillimeter properties of galaxies located behind the Bullet cluster

M. Rex

The Herschel Lensing Survey (HLS) takes advantage of gravitational lensing by massive galaxy clusters to sample a population of high-redshift galaxies which are too faint to be detected above the confusion limit of current far-infrared/submillimeter telescopes. Measurements from 100-500μm bracket the peaks of the far-infrared spectral energy distributions of these galaxies, characterizing their infrared luminosities and star formation rates. We introduce initial results from our science demonstration phase observations, directed toward the Bullet cluster (1E0657-56). By combining our observations with LABOCA 870μm and AzTEC 1.1 mm data we fully constrain the spectral energy distributions of 19 MIPS 24μm selected galaxies which are located behind the cluster. We find that their colors are best fit using templates based on local galaxies

with systematically lower infrared luminosities.This suggests that our sources are not like local ultra-luminous infrared galaxies in which vigorous star formation is contained in a compact highly dust-obscured region. Instead, they appear to be scaled up versions of lower luminosity local galaxies with star formation occurring on larger physical scales.

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P22. Testing the suitability of infrared luminosity as a reliable star formation rate indicator at z~1

N. Rodríguez-Eugenio, J. A. Acosta-Pulido, A. Manchado, DEEP2 Team & the AEGIS Collaboration

The advent of deep mid- and far-infrared surveys has enabled star formation rate (SFR) studies for large samples of intermediate- and high-redshift galaxies, using the infrared (IR) emission as a SFR indicator. This approach relies on two basic assumptions: first, all the light produced by recently formed stars is absorbed by dust and re-emitted in the IR; and second, the dust heating by evolved stellar populations is negligible. This is the case for dusty starburst galaxies at low redshifts, but the reliability of the IR emission as a quantitative SFR tracer in typical star-forming galaxies at higher redshifts needs to be tested.

We combine extinction-corrected Hα luminosities obtained with the multi-slit mode of LIRIS/WHT, with ultraviolet (UV) continuum, and total IR luminosities (obtained from SED fitting to optical-NIR and MIPS/ Spitzer 24μm fluxes), to derive a reliable IR-based SFR indicator by estimating the fractions of nonionizing, ε, and ionizing, f_{dust}, UV luminosity absorbed by dust, and the contribution to dust heating by evolved stellar populations, η, in star-forming galaxies at z~1. The studied sample is composed of 30 normal star-forming galaxies and LIRGs in the redshift range 0.8 <~ z <~ 1.0 drawn from the DEEP2 and AEGIS surveys. We find the following mean values for the studied parameters: ε ~ 0.8, η ~ 0.4, and f_{dust} ~ 0.1. Dust attenuations affecting nonionizing and ionizing UV photons exhibit opposite trends with the galaxy stellar mass, SFR, and color, in the sense that the former shows clear positive correlations with these quantities, and the latter shows anticorrelations. We also find that the IR luminosity alone provides a good estimation of the SFR for dusty z~1 star-forming galaxies, since the contribution to dust heating by evolved stellar populations and the effect of finite dust opacity of UV photons almost cancel each other out.

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P23. The dust content of high-z submillimeter galaxies revealed by Herschel

P. Santini

I will present recent results obtained with SDP PACS-Herschel data, which have been used to measure the dust mass in a sample of high-z submillimeter galaxies (SMGs). We investigated their dust content relative to their stellar and gas masses, and compared them with local star-forming galaxies. High-z SMGs have higher dust-to-stellar mass ratios compared to local spiral galaxies and also compared to local ULIRGs. This indicates that the large masses of gas typically hosted in SMGs have already been highly enriched with metals and dust. Indeed, their dust-to-gas ratios are similar or higher than in local spirals and ULIRGs. However, the large dust content observed in SMGs, as inferred from the far-IR and submm data, is in contrast with their low gas metallicity measured from optical nebular lines. I will discuss the possible explanations of this discrepancy.
Finally, complementary results from the analysis of more recent Herschel data will be presented and discussed.

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P24. Mid-Infrared Properties of Luminous IR Galaxies: The Effects of Star Formation and AGN on PAHs at z=0

S. Stierwalt

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.

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P25. Spitzer Extragalactic Representative Volume Survey (SERVS) Early Science

M. Vaccari, M. Lacy, D. Farrah & The SERVS Consortium

We present the Spitzer Extragalactic Representative Volume Suvey (SERVS), an 18 deg^2 medium-deep survey at 3.6 and 4.5 μm with the post-cryogenic Spitzer Space Telescope to ~ 2 muJy (AB = 23.1) depth.

SERVS is designed to enable the study of galaxy evolution as a function of environment from z ~ 5 to the present day, and is the first extragalactic survey both large enough and deep enough to put rare objects such as luminous quasars and galaxy clusters at z >~ 1 into their cosmological context. SERVS is designed to overlap with several key surveys at optical, near- through far-infrared, submillimeter and radio wavelengths to provide a coherent picture of the formation of massive galaxies. In this talk, we discuss the SERVS data, ancillary data from other surveys in the SERVS fields, outline the main science topics that SERVS will address and present SERVS Early Science results ranging from the IRAC ultra-deep observations of radio sources to the detection of z~1 cluster candidates through Voronoi tessellation and Optical/NIR/MIR color selection and the determination of their composite stellar mass function, from the number counts and angular clustering of SERVS sources to IRAC stacking studies aimed at characterizing the environments in which high-redshift QSOs reside.

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P26. The K-z relation and the radio structure of the TOOT00 and the SXDS radio sources

E. Vardoulaki

We present a near-infrared (K-band) study of two independent radio-source samples, the 151-MHz radio selected TOOT00 and the 1.4-GHz radio selected SXDS radio sources, and compare them to other samples from the literature. Comparison to the K_W-z relation of Willott et al. suggests that both the TOOT00 and SXDS radio galaxies obey the same K-z relation defined by 3CRR/6CE/6C/7CRS radio galaxies. The median luminosity at K for the TOOT00 and the SXDS objects is $L_{K\text{-}Ke\text{-}apcor}$~4 L^*_K with very few faint outliers, adding to examples identified before. Nearly all TOOT00 objects are simple analogues of bright galaxies in the local (z_{med}=0.08) 6dF sample of Mauch & Sadler, apart from sub-L_K* objects, but in the SXDS, high-z sources probe enough cosmic volume at deep enough K depths to find a population of objects not seen locally. These sub-L_K* objects at z~1, $L_{1.4GHz}$~ 10^{24} $WHz^{-1}sr^{-1}$, are found in various high-z radio-source samples, like CENSORS and MRCR-SUMSS, but they are rare and might be young dusty galaxies.*
Finally, the FRI/FRII divide in radio luminosity seen at z<<0.5 is also obeyed at z~1 for FRII objects in the TOOT00 and SXDS samples, but examples of FRI radio sources that are above the FRI/FRII break in radio luminosity are rare but exist in both samples, and can also be seen in the local 6dF sample.

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P27. Mid-infrared triggers for OH megamaser production

K. Willett

OH megamasers (OHMs) are extremely powerful 18-cm masers found in the nuclear regions of merging ULIRGs. We present mid-infrared spectra of 56 OHMs obtained with the Spitzer IRS and contrast these with 15 galaxies confirmed to have no megamaser emission. We find that the IR emission in OHMs is dominated by starbursts, with non-masing ULIRGs showing a much higher AGN fraction than OHMs. OHM hosts also have higher PAH equivalent widths, deeper silicate absorption, more detections of absorption by crystalline silicates, ices, and gas-phase molecules, and show a much lower rate of high-ionization NeV and OIV emission. Column densities of OH derived from the 34.6 μm OH feature are similar to those derived from 1667 MHz OH absorption in non-masing galaxies, indicating that the abundance of masing molecules is similar in both samples. Modeling the dust features reveals that non-masing galaxies are better fit by clumpy dust geometries commonly associated with AGN, while OHMs have deeper absorption consistent with a smoother, thicker dust shell. We compare our results to new OH pumping models and find that dust temperatures of 40-80 K are in good agreement with predictions. The best-fit opacities (τ_V=100-400), however, are nearly an order of magnitude larger than initially expected for OH inversion. These diagnostics offer the first detailed test of an OHM pumping model based only on the properties of its host galaxy and provide important restrictions on the physical conditions necessary to make an OHM.

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P28. The far-infrared continuum of M33

E. Xilouris, C. Kramer & the HERM33ES Consortium

We study the far-infrared emission from the nearby spiral galaxy M33, observed with Herschel Space Observatory as part of the Herschel M33 Extended Survey (HERM33ES), in order to investigate dust physical properties like temperature and surface density across the galaxy. Taking advantage of the unique wavelength coverage (100, 160, 250, 350 and 500μm) of the Herschel Space Observatory we construct temperature and column density maps of the dust by fitting a combination of two grey bodies of a fixed emissivity index of 1.5.

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P29. Infrared Study of an Interacting Galaxy sample

A. Zezas

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NOTES

Designed and Prepared by
Elisabete da Cunha
14 September 2010