Talks:

David M Alexander (*Durham University*)
Infrared Identification of Hidden AGNs in the Deepest X-ray Fields
I will review our ability to identify the sites of obscured AGN activity using X-ray and infrared observations. I will show that infrared observations, particularly those covering a broad range from ~3-250um can reliably identify even comparatively weak AGN components. Approximately half of the AGNs are unidentified even in the deepest X-ray observations and are likely to be very heavily obscured (many will be Compton thick). I will discuss how these results in the context of of the growth of black holes.

Kentaro Aoki (*Subaru Telescope*)
Mid-Infrared selected quasars in WISE Preliminary Data Release
Recent studies show that dust reddened quasars tend to exist in major-mergers and are accompanied with outflow phenomena. The iron low-ionization broad absorption-line quasars (FeLoBALs), for example, show broad blueshifted absorption lines and are significantly redder than normal quasars. They may be in transition phase from starburst galaxies to normal quasars, and thus they are an important population to study the co-evolution of AGN and their host galaxies. Searching for reddened quasars and to know their numbers and fraction among the entire quasars are the fundamental steps. The longer wavelength is better to search for reddened quasars, and mid-infrared (MIR) colors have advantage in separation of quasars from stars than optical colors. We carried out MIR color selection of quasars in WISE Preliminary Data Release. We defined the color space on the [4.6]-[12] vs. [3.4]-[4.6] plane considering real SDSS quasars' WISE colors and the color tracks of template galaxies including spirals, LIRGs and ULIRGs. Our MIR color selection recovers > 90% SDSS quasars detected by WISE at $z < 2.2$. This color selection also recovers 100% known FeLoBALs detected WISE at $z < 2.0$. It is interesting that MIR colors of known FeLoBALs are similar to normal quasars although optical colors of FeLoBALs are significantly redder. It is suggested that optical reddening in FeLoBALs does not come

from the dusty torus which affects MIR colors. By applying our MIR color selection to WISE sources in high galactic latitude (|b| > 30 deg), we selected 800,000 quasar candidates. In order to examine the characteristics of MIR selected quasar candidates, we picked up a region (20x20 deg^2) which both WISE and SDSS cover. There are 35,000 MIR selected quasar candidates in this region, and among them 24% candidates are not associated with SDSS sources. They are redder by 0.3 mag in [4.6]-[12] color than SDSS-associated candidates. It is already known that a simple MIR color cut to select AGN suffers from considerable contamination from non-AGN galaxies. We estimated the contamination using the region mentioned above. Among 27,000 SDSS-associated quasar candidates 47% of them are classified as the extended source by SDSS. Such "extended" candidates have systematically different MIR colors, and resemble to "LIRG" colors. We therefore discovered many new SDSS-missed quasar candidates and will do follow up observations to reveal their possibly interesting nature.

Roberto J Assef (*JPL*)
WISE Selection of Obscured and Unobscured AGN
WISE is a uniquely efficient tool for finding active galactic nuclei (AGNs), identifying luminous AGN essential independent of the obscuration of the active nucleus. We discuss the WISE selection of AGN using SED modeling techniques, using the vast amount of μlti-wavelength photometric and spectroscopic observations in the 10 deg2 NOAO Deep, Wide-Field Survey Bootes field (also known as the Spitzer Deep, Wide-Field Survey and XBootes) and the COSMOS field. We discuss the biases and contamination of the mid-IR color AGN selection, and the physical properties of objects found by WISE.

Andrew J Baker (*Rutgers, the State University of New Jersey*)
High-Redshift Galaxies in the ALMA Era
Progress in understanding galaxy formation and evolution has often been driven by new telescopes and instruments that access unexplored volumes of observational parameter space. This pattern is especially clear in the case of dusty galaxies, ranging from the discovery of ultraluminous infrared galaxies with IRAS to that of submillimeter galaxies with SCUBA. In this talk, I will discuss recent progress in understanding dusty galaxies at high redshift that has been delivered by the combination of wide-area continuum surveys with Herschel and wide-bandwidth CO spectroscopy with the Zpectrometer on the NRAO Green Bank Telescope. I will also offer a perspective on some of the exciting future opportunities in this area that will be

afforded by the Atacama Large Millimeter/submillimeter Array (ALMA) as it moves from its present "Early Science" phase to full operations.

Dominic J Benford (*NASA / GSFC*)
2 Millimeter Ultra Deep Field Observations
As illustrated by recent observations with the GISMO 2 mm bolometer camera at the IRAM 30m Telescope, we have obtained observational capabilities to obtain near confusion limited deep field observations in the 2mm band, with an angular resolution of ~ 16". We will discuss the scientific potential of such deep surveys, including spectroscopic follow up.

Andrew J Benson (*Caltech*)
Modelling the sub-mm population: Challenges and Prospects
I will present results from an ongoing project which is constructing virtual Universes populated with sub-mm galaxies. These consist of catalogs of galaxies in square degree fields of view out to redshifts of at least 6. Galaxy properties are computed using a combination of high resolution N-body siμlations of large scale structure and physical models of galaxy formation and radiative transfer of starlight through dust. This results in a virtual universe within which galaxies have fully specified spatial (comoving positions, angular coordinates, redshift including peculiar velocity), spectral (full SED from UV to radio wavelengths, including PAH features) and physical (star and gas masses and metallicities, star formation rate, merger history etc.) properties. Once complete, the full datasets will be made available to the comμnity. I will describe some of the challenges in making robust predictions for sub-mm surveys and will assess prospects for using these techniques to extract understanding on the underlying physics from current and future surveys.

Stefano Berta (*Max Planck Institute for Extraterrestrial Physics*)
The Properties of Herschel/PEP Star Forming Galaxies
I will present recent results of the PACS Evolutionary Probe (PEP) extragalactic survey. PEP observed popular multi-wavelength fields from wide (COSMOS, 2 deg2) to deep, pencil-beam observations (e.g. GOODS-N/S) and lensing galaxy clusters at 70, 100 and 160 microns.

Herschel observations break the confusion limit of previous infrared space telescopes and cover the whole flux range from ~1 mJy to 200 mJy, thus resolving more than 70% (55%) of the Cosmic IR background (CIB) at 160 microns (100 micron).

The properties of $0.7 < z < 3.0$ infrared (IR) galaxies

are studied along and across the so-called "main sequence" (MS) of star forming galaxies. We explore the relationship between SED shape and offset from the redshift-dependent MS: while mid-to-far IR colors keep roughly constant along the MS regardless of L(IR), galaxies become increasingly "red" as they move off the MS. The study of ultra deep IRS spectra confirms that this effect is mostly due to a change in the PAH/L(IR) ratio, rather than to a possible hidden AGN component.

Combining PACS-derived calorimetric star formation rates and ancillary datasets, the dependence of galaxy structure and other internal parameters (e.g. extinction and timescale of star formation) was also explored. The correlation between the structure and stellar population of galaxies (i.e., a "Hubble sequence") was already in place since at least z~2.5. At all epochs, typical star-forming galaxies on the MS are well approximated by exponential disks. In the upper envelope of the MS, the relation between the SFR and Sersic index reverses, suggesting a rapid build-up of the central mass concentration in these starbursting outliers. At each mass and redshift, galaxies on the main sequence have the largest size. The rate of size growth correlates with specific SFR, and so do SFR surface density and obscuration.

Finally, combining PACS and SPIRE data, our study extensively covers also the most extreme objects, historically known as sub-millimeter galaxies (SMGs). An unprecedented collection of 63 such systems is exploited to shed light on their properties. Our results unambiguously reveal the heterogeneity of the SMG population, including both high luminosity (< 1e13 Lsun) merger-driven systems, and lower luminosity, colder, secularly evolving objects.

Andrew W Blain (*University of Leicester*)
Obscured AGN samples highlighted by WISE.
I will describe several AGN samples that can be better understood by combining data from the WISE mission with existing catalogs. These include the ROSAT all-sky survey, the large QSO samples from SDSS and 2df/6df, high-redshift samples constructed from optical/near-IR surveys at z>5.7, and the opportunity to follow up the existing combination of all-sky X-ray/radio and IRAS samples.

James J Bock (*JPL*)
The HerMES Extragalactic Survey Program
The Herschel Multi-tiered Extragalactic Survey (HerMES) is an extragalactic far-infrared imaging program using the Herschel PACS and SPIRE instruments to cover ~350 square degrees to variable depth in well-studied fields. The survey takes

maxiμm advantage of the μlti-wavelength data available in these fields, and is coordinated with the Herschel PACS Extragalactic Probe (PEP) survey. HerMES is addressing fundamental questions in far-infrared galaxy evolution, including the total infrared emission of galaxies, the evolution of the luminosity function, the clustering properties of dusty galaxies, and the properties of populations of galaxies below the confusion limit through lensing and statistical techniques. We discuss recent results from HerMES and plans for future work.

Nicholas A Bond (*NASA Goddard*)
The Mid- and Far-IR Properties of Sources Detected in Both the Herschel ATLAS and WISE Surveys
We describe the infrared properties of sources detected in both the Herschel Astrophysical Terahertz Large-Area Survey (H-ATLAS) and Wide-field Infrared Survey (WISE). With point-source depths of 34 and 0.06 mJy at 250 micron and 3.4 micron, respectively, we find that 55\% of H-ATLAS sources can be reliably identified in the WISE survey, including a strong majority (~88%) of objects with existing spectroscopic or optical/near-IR photometric redshifts. The majority of the matched sources without previously measured redshifts are likely at z>1.5 based on their 250-350 micron and 500-350 micron flux ratios. Of the matched sources with detections at both 3.4 and 4.6 micron, we find that 14.8% are AGN, including 7.6% of those with spectroscopic redshifts. In addition, for sources with spectroscopic redshifts at z<0.4, we find a linear correlation between the infrared luminosity at 3.4 micron and that at 250 micron, with ~60% scatter over two orders of magnitude in luminosity.

David G Bonfield (*University of Hertfordshire*)
Herschel-ATLAS: The relationship between accretion luminosity and star formation in QSO hosts
We use the science demonstration field data of the Herschel-ATLAS to study how star formation, traced by the far-infrared Herschel data, is related to both the accretion luminosity and redshift of quasars selected from the Sloan Digital Sky Survey and the 2SLAQ survey. By developing a maxiμm likelihood estimator to investigate the presence of correlations between the far-infrared and optical luminosities we find evidence that the star-formation in quasar hosts is correlated with both redshift and quasar accretion luminosity. Assuming a relationship of the form L_IR \propto L_QSO^θ (1 + z)^ζ, we find θ = 0.22 +/- 0.08 and ζ = 1.6 +/- 0.4, although there is substantial additional uncertainty in ζ of order +/- 1, due to uncertainties in the host galaxy dust temperature. We find evidence for a large intrinsic dispersion in the redshift dependence, but no

evidence for intrinsic dispersion in the correlation between L_QSO and L_IR, suggesting that the latter may be due to a direct physical connection between star formation and black hole accretion. This is consistent with the idea that both the quasar activity and star formation are dependent on the same reservoir of cold gas, so that they are both affected by the influx of cold gas during mergers or heating of gas via feedback processes.

Carrie Bridge (*Caltech*)
WISE-Selected Lyman-alpha "blobs": A Dusty High-z Population in Transition
Using the all sky data from NASA's Wide-field Infrared Survey Explorer (WISE), coupled with Keck spectroscopy, we have confirmed a new mid infrared color-selection that identifies z>2 dusty Lyman-alpha emitters (LAEs). Remarkably, at least 30% of the sources show extended Lyman-alpha emission, on spatial scales of 40-100 kpc, akin to Lyman-alpha "blobs". Unlike optically identified Lyman-alpha blobs however, our sources are all extremely IR-luminous (L_IR>10^12-13), and appear to be caught in the brief transition between a dusty starburst and an optical QSO. This population is thus ideal for understanding two important issues; (1) the interplay between star formation and AGN activity at high redshift, which has fundamental implications for the cosmological history of galaxy assembly, and (2) the general phenomenon of extended Lyman-alpha emission in galaxies, which remains a poorly understood topic. I will present the properties of these galaxies as derived from optical through far-IR observations, discuss possible mechanisms behind the extended Lyman-alpha emission, and place them in context with other high redshift populations.

Denis Burgarella (*Laboratoire d'Astrophysique de Marseille*)
Herschel FIR First Detections of Lyman Break Galaxies: at 0.5 < z < 5.0
Lyman Break Galaxies (LBGs) are selected by their UV color and they provided the astronomers with the first and (still) largest sample of high redshift galaxies. Their ultraviolet and optical properties are rather well constrained and they appear to be starburst galaxies. However, since the very beginning, one question was not satisfactorily addressed: what is their infrared luminosity or, in other words, how μch dust attenuation is necessary to evaluate their total star formation rate (SFR) ? Spitzer and AKARI allowed us to start addressing this point but only at z~1. Herschel is going one step further and we detected hundreds of LBGs at z~2 and a few tens at z>3 (some of them with spectroscopic redshift) in the COSMOS field. We will report on these detections and try to understand what they mean in terms of galaxy evolution and

assess the possible links between LBGs and other types of high redshift galaxies by comparing their properties to other observed objects (e.g. LBGs, LAEs, ...) and to an evolutionary model that we built.

Asantha Cooray (*UC Irvine*)
Studies of gravitationally lensed faint, sub-confusion Sub-mm sources
This talk with present results from a coordinated, two-year long effort to followup close to 200 lensed sub-mm galaxies identified with Herschel-SPIRE in HerMES (and to some extent from Herschel-ATLAS) at μlti-wavelengths from UV to radio with ground and space-based facilities, including Spitzer and HST. The redshift distribution, intrinsic source properties, statistical properties on gas, dust, and stellar mass will be presented. Depending on time we will also discuss the nature of faint sources that dominate the cosmic far-IR background, both from lensing of individual source studies and through anisotropy measurements of the far-IR background.

Emanuele Daddi (*CEA Saclay*)
Unveiling Different Modes of Star Formation in the Distant Universe
I will discuss evidence for different star formation modes in starburst versus normal galaxies, based on Herschel far-IR and IRAM millimetric observations of distant galaxies. I will discuss what we have started to learn in terms of the nature of star formation, and the role of AGNs in this scheme. I will try to emphasize key uncertainties and open questions of this picture which are relevant for understanding galaxy evolution.

Jeremy Darling (*University of Colorado*)
Mining the Sky with WISE: Extreme Starbursts Spoofing HI and Other Oddities
We describe a data mining project using the WISE preliminary data release that identifies extreme starburst galaxies and major mergers using the ALFALFA HI 21 cm line survey and optical spectroscopy. There is a subset of apparent HI 21 cm lines that are in fact OH megamasers arising in ultraluminous IR galaxies at higher redshift, and this "contamination" component will become the dominant line at some redshift in any HI survey. WISE provides a means to identify the starbursts among the more quiescent galaxies. WISE has also revealed a very peculiar and mysterious line-emitting object of unknown nature. It is likely that more such objects will be discovered through the mining of overlapping surveys spanning the electromagnetic spectrum. This work will be an essential guide for future high redshift HI surveys, particularly those using the upcoming Square Kilometer Array precursor observatories.

Mark Dickinson (*NOAO*)
GOODS-Herschel: The deepest view of the far-infrared skies
I will present a review of early results from the GOODS-Herschel project, the deepest direct imaging survey with the Herschel PACS and SPIRE instruments. These data are providing new insights into the bolometric emission from "normal" galaxies and active galactic nuclei at high redshift, and complement the wealth of additional information on galaxy evolution available from other μltiwavelength GOODS-related surveys.

Jennifer Donley (*STScI*)
Identifying Luminous AGN in Deep Surveys: Revised IRAC Selection Criteria
Spitzer IRAC selection is a powerful tool for identifying luminous AGN. The AGN selection wedges currently in use, however, are heavily contaminated by star-forming galaxies, especially at high redshift. Using the large samples of luminous AGN and high-redshift star-forming galaxies in COSMOS, we redefine the AGN selection criteria for use in deep IRAC surveys. The new IRAC criteria are designed to be both highly complete and reliable, and incorporate the best aspects of the current AGN selection wedges and of infrared power-law selection while excluding high redshift star-forming galaxies selected via the BzK, DRG, LBG, and SMG criteria. At QSO-luminosities of log Lx (ergs/s) > 44, the new IRAC criteria recover 75% of the hard X-ray and IRAC-detected XMM-COSMOS sample, yet only 37% of the IRAC AGN candidates have X-ray counterparts, a fraction that rises to 51% in regions with Chandra exposures of 50-160 ks. X-ray stacking of the individually X-ray non-detected AGN candidates leads to a hard X-ray signal indicative of heavily obscured to mildly Compton-thick obscuration (log NH > 23.7). While IRAC selection recovers a substantial fraction of luminous unobscured and obscured AGN, it is incomplete to low-luminosity and host-dominated AGN.

Emilio Donoso (*Caltech*)
Origin of 12 micron Emission Across Galaxy Populations from WISE and SDSS
The recent data release of the Wide-field Infrared Survey Explorer (WISE) provides the astronomical comμnity with the most comprehensive view of galaxies in the near and mid-infrared. We cross-matched WISE 12 micron sources brighter than 1 mJy with the spectroscopic SDSS to produce the largest sample of its kind, consisting of ~10^5 objects at =0.08, with total IR luminosities in the range ~10^8-10^11 L_sun. We investigate basic physical properties of 12 micron galaxies, demonstrating that WISE 12 micron is efficient in selecting normal star forming galaxies (SF) and that

SDSS composite systems, with “green” (u-r) colors, tend to be dusty and IR bright. We explore in detail the relationships between 12 micron emission and stellar mass, optical star formation rate (SFR) and specific SFR (SSFR). The main result is that SF galaxies, composite systems and AGN follow different correlations, largely due to the difference in their stellar populations. SF galaxies and weak AGN show divergent behavior in the L(12um) - SFR space. At SFR~ (0.02-1) M_sun/yr weak AGN have excess of 12 micron emission, while SF galaxies tend to have slightly lower IR luminosity at a given SFR. We suggest that the former effect is due to dust heated by relatively old stellar populations (~3 Gyr), while the later is because of the increasing transparency of low mass, high metallicity galaxies. After removing the trends with mass and metallicity, the SSFR of SF galaxies is nearly constant for all luminosities probed, whereas the SSFR of weak and strong AGN decreases ~3 orders of magnitude as the IR luminosity decreases. This reflects the different star formation efficiency between SF galaxies and early-type massive galaxies with older stellar populations. In addition, the [4.6-12] micron IR color correlates well with the SSFR, serving as a useful first-order indicator of the overall SF activity in a galaxy of any given type when no other data is available.

C. Darren Dowell (*JPL*)
Discovery of High-Redshift Galaxies with Herschel/SPIRE

We report on ongoing efforts with Herschel/SPIRE to identify candidate high-redshift galaxies, based on their cold/red spectral energy distributions. We describe follow-up observations, demonstrating that several of these galaxies are at $z > 4$.

Peter Eisenhardt (*JPL/Caltech*)
The Reddest Extragalactic WISE Sources: Hot DOGs?

One of the two primary science objectives for NASA's Wide-field Infrared Survey Explorer (WISE) is to identify the most luminous galaxies in the Universe. We have used WISE photometry to select an all-sky sample of ~1,000 objects which are extremely luminous. The sources are prominent at 12 microns (W3) or 22 microns (W4), but faint or undetected at 3.4 microns (W1) and 4.7 microns (W2), and hence referred to as “W12drops.” I will provide an overview of several programs to follow up the objects. Observations of the full sample with Spitzer are largely complete, confirming that W12drops are redder than previously identified populations. Spectroscopy of ~100 W12drops shows that the majority have $z > 1.6$. Herschel PACS and SPIRE photometry for a subsample of 91 is underway, and sub-millimeter and millimeter data have been obtained for approximately a dozen

sources. These reveal SEDs that tend to peak below rest frame 100 microns, so that hot dust dominates the bolometric luminosity, which can exceed 100 trillion solar luminosities. Optical and near-IR imaging programs, including adaptive optics and HST, are in progress. These will address whether lensing is a major factor in the population. Modeling of one W12drop suggests the luminous AGN phase may precede galaxy formation, contrary to prevailing ideas. We suggest these hot, dust-obscured galaxies, or hot DOGs, represent a rare transitional stage in the interplay between the formation of galaxy bulges and super-massive black holes.

Duncan Farrah (*University of Sussex*)
Mid- to Far-infrared Diagnostics of AGN Feedback in IR-luminous Galaxies and QSOs
The idea that 'feedback' from active galactic nuclei may profoundly affect star formation in their host galaxies is rapidly becoming a core element in many theoretical models, yet observational constraints on feedback are difficult to achieve. In this talk I will first briefly review the concept of AGN feedback, before presenting results from Herschel, Spitzer and WISE that quantify the presence of AGN feedback in both ULIRGs and QSOs, and its role in curtailing star formation.

Claude-Andre Faucher-Giguere (*UC Berkeley*)
Modeling AGN Outflows: Implications for Feedback Efficiency
Feedback from active galactic nuclei is believed to produce the observed correlations between the spheroid components of galaxies and their central supermassive black holes, as well as to play a key role in establishing the red sequence. How the energy and momentum from black holes couples to the interstellar medium however remains an open question. I will describe new physical models of AGN outflows, specifically those recently studied via low-ionization broad absorption lines and in molecular emission (with Herschel and in the radio/sub-mm). I will show how the physical models allow us to interpret the observations more accurately, and to derive more robust constraints on the efficiency of feedback onto galaxies.

David T Frayer (*NRAO*)
GBT and the EVLA Results and Opportunities on the Evolution of Gas in Luminous Infrared Galaxies
I will report on our ongoing Green Bank Telescope [GBT] CO(1-0) observations of the Herschel ATLAS high-redshift submillimeter galaxies [SMGs] using the Zpectrometer instrument and our GBT neutral hydrogen observations of the local GOALS luminous infrared galaxies. We find similar star-formation efficiencies [L(IR)/L'(CO)] for the

Herschel SMGs as those found in local ULIRGs. With the large GBT GOALS sample, we are able to measure a trend in L(IR)/M(HI) ratios with infrared luminosity similar to that found previously with L(IR)/L'(CO). I will discuss the GBT results as well as recent EVLA CO(1-0) results on our understanding of the evolution of gas in galaxies, and will highlight GBT and EVLA capabilities that will provide additional opportunities in the field.

Poshak Gandhi (*ISAS / JAXA*)
Mid-infrared studies of X-ray binaries: a new window on accretion and outflows
WISE has thrown open a new window on the search for non-thermal emission from X-ray binaries (XRBs). Binary systems with either a black hole or neutron star accreting compact object are known to display broad-band emission from the accretion disk (in the optical/UV/X-rays) and from relativistic outflowing jets in the radio. The peak flux density of synchrotron emission from compact XRB jets ought to be peak in the infrared, but a variety of observational and sensitivity limitations have precluded secure detection of this peak thus far. In fact, many XRBs still remain undetected in the mid-infrared. We now show clear detections of a well-known black hole XRB GX 339-4 in all four WISE bands during an active accretion state in March 2010. In conjunction with a suite of contemporaneous radio to X-ray μltiwavelength observations, we find strong evidence that the mid-infrared is jet-dominated. Not only are we able to constrain the position of the jet peak flux density, but we also find dramatic mid-infrared variability (flux changes by factors of ~3 in a few hours) in the WISE orbital (L1b) data. The spectral frequency associated with the peak is seen to vary across the entire WISE bandpass. Detection of the mid-infrared spectral peak and variability provide key quantitative constraints on the jet physical parameters (e.g. magnetic field strength, size of the plasma acceleration zone), and demonstrate that these parameters can be modulated by large factors of ~10 on relatively-short timescales. I will show that the potential for infrared studies of XRBs is enormous, and WISE is likely to be a game-changer in this field.

Eilat Glikman (*Yale University*)
FIRST-2MASS Red Quasars: Transitional Objects Emerging from the Dust
We present a sample of 116 dust-reddened quasars identified by matching radio sources with the near-infrared 2MASS catalog and color-selecting red sources. We followed up our candidates with optical and/or near-infrared spectroscopy, providing broad wavelength sampling of their spectral energy distributions that we use to determine their reddening, E(B-V). This is the largest sample of red

quasars to date, spanning a wide range in redshift and reddening ($z < 3$, $0.1 < E(B-V) < 1.5$). With such a large sample we can investigate the effect of luminosity on reddening and its evolution with redshift. We find that, at every redshift, dust-reddened quasars are intrinsically the most luminous quasars compared with unreddened quasars. We interpret this in the context of merger-driven quasar/galaxy co-evolution where these reddened quasars are revealing an emergent phase where the heavily obscured quasar is shedding its cocoon of dust prior to becoming a "normal" blue quasar. We estimate, based on the fraction of objects in this phase, that its duration is ~20% as long as the unobscured quasar phase, a few million years.

Anthony H Gonzalez (*University of Florida*)
A WISE View of Galaxy Clusters
In this talk I will present recent results for both nearby and distant galaxy clusters based upon the WISE all-sky survey. At low redshift, I will show from a systematic study of star formation in 69 local galaxy clusters using 22μm from WISE. The all-sky WISE data enables us to quantify the amount of star formation, as traced by 22μm, as a function of radius well beyond R200, and investigate the dependence of total star formation rate upon cluster mass. We find that the fraction of star-forming galaxies increases with cluster radius, but remains below the field value even at three times R200. At higher redshift WISE also provides a unique capability for detecting the most massive galaxy clusters in the Universe out to z=1.5. I will show initial results from a survey that we have undertaken to identify such systems in the WISE Preliminary Data Release region.

Javier Gracia Carpio (*Max Planck Institute for Extraterrestrial Physics*)
SHINING: studying physical processes in the interstellar media of galaxies
I will review some of the recent results from the Herschel guaranteed time key program SHINING. Using the PACS spectrometer we are studying the far-infrared properties of a sample of more than 100 galaxies that includes local starbursts, Seyfert galaxies, low-metallicity systems, and infrared luminous galaxies at low and high redshift. We find that galaxies with extreme Lfir/MH2 ratios tend to have weaker fine structure lines relative to their far-infrared continuum. We interpret these line deficits as an effect produced by the much higher values of the ionization parameter in these galaxies. I will also show the detection of massive molecular outflows, traced by the hydroxyl molecule (OH), in the far-infrared spectra of several ultraluminous infrared galaxies and discuss the implications of these results on the evolution of their molecular gas content. The effects of AGN radiation on the properties of the

interstellar medium will also be discussed.

Hitoshi Hanami (*Iwate University*)
Star Formation and AGN activity in Dusty Galaxies Classified with MIR SED diagnosis at z = 0.4-2
We have studied the star-forming and AGN activity of massive galaxies in the redshift range z=0.4-2, which are detected in a deep survey field using the AKARI and *Subaru* telescopes toward the North Ecliptic Pole (NEP). The AKARI/IRC Mid-InfraRed (MIR) μltiband photometry could trace their star-forming/AGN activity, with/without the Polycyclic-Aromatic Hydrocarbon (PAH) emission bands at 6.2, 7.7 and 11.3 μm in MIR detected galaxies up to z ≅ 2. These data can be used to distinguish star-forming populations from AGN dominated ones, and to estimate the derived Star Formation Rate (SFR) from their total emitting InfraRed (IR) luminosities. The μlti-wavelength survey, expanding from the optical to Mid-InfraRed (MIR) wavelengths, could allow us to reconstruct Colour-Magnitude Diagram (CMD) for the detected galaxies and analyze evolutionary trends of their stellar populations, which are also confirmed with classifications as Balmer Break Galaxies (BBGs) and Infra-Red (IR) Bump Galaxies (IRBGs) in three redshift ranges of z=0.4-0.8, 0.8-1.2, categorised with two colour criteria characterising Balmer/4000 AA break and AKARI NIR colours detecting 1.6 μm bump. Combining with the analysis for thier stellar components, thus, we have studied the MIR SED features of star-forming/AGN-harboring galaxies, which we summarise below: 1) The rest-frame 7.7 μm (5μm) luminosity is a good tracer of star-forming (AGN) activities as the PAH emissions (dusty tori emissions) from galaxies even up to z ≅ 2, 2) The SFR derived from their 7.7 μm luminosity shows a correlation that is nearly proportional to the stellar mass The specific SFR (sSFR) per unit stellar mass rises with redshift at all stellar masses, and are nearly constant, or show a weak dependence on stellar mass M_*, 3) The MIR detected star-forming galaxies show that calorimetric extinction from tIR and uncorrected UV luminosities tends to be ~ 2 magnitudes larger than classical extinction from optical SED fittings, which may be caused from geometric variations and concentrations of dusts. 4) The AGN activities derived from their rest-frame 5 μm luminosity suggest that their Super Massive Black Holes (SMBH) could already have grown to ~ 3 imes 10^8 M_{sun} in maximum population with 10^12 L_{sun} and 10^11 M_{sun} in the MIR selected AGNs at z>1.2, suggesting that the mass relation between the SMBH and its host has already become established by z ≅ 1-2.

Fiona Harrison (*Caltech*)

NuSTAR Measurements of AGN Obscuration in the Local Universe

The Nuclear Spectroscopic Telescope Array (NuSTAR) will carry into orbit the first astronomical telescope capable of focusing high-energy X-rays in the 5 - 80 keV band. NuSTAR will provide a combination of sensitivity, imaging and energy resolving power a factor ten to one hundred times better than any previous mission that has operated at these energies. Because of the penetrating power of high-energy X-rays, NuSTAR can probe dusty regions of the Galaxy and Universe to reveal stellar mass compact objects as well as obscured AGN. In this talk I will describe the mission parameters, and the baseline science program aimed at revealing the population and nature of obscured AGN up to redshifts of two.

Jeyhan S Kartaltepe (*NOAO*)

The Role of Galaxy Mergers Among High Redshift ULIRGs

In the local universe, Ultraluminous Infrared Galaxies (ULIRGs, L_IR > 10^{12} L_sun) are all interacting and merging galaxies. To date, studies of ULIRGs at high redshift have found a variety of results due to their varying selection effects and small sample sizes. Some studies have found that mergers still dominate the galaxy morphology while others have found a high fraction of morphologically normal or clumpy star forming disks. Near-infrared imaging is crucial for interpreting galaxy structure at high redshift since it probes the rest frame optical light of a galaxy and thus we can compare directly to studies in the local universe. Here, we present the results of a morphological analysis of a sample of high redshift (z~1-3) ULIRGs. These galaxies are selected based on their infrared luminosities measured using 100 and 160 micron data from the GOODS-Herschel coverage of GOODS-S. We visually classified all of the ULIRGs as well as a comparison sample with the same redshift and H band magnitude range using ACS and WFC3 data from the GOODS and CANDELS surveys. We compare our results to those from other classifiers as well as several automated classification methods. The high resolution and increased sensitivity of WFC3 over NICMOS for this large sample of objects allows us to investigate the role of galaxy mergers among high redshift ULIRGs consistently for the first time. Additionally, we address the role of AGN among this high redshift sample using several selection techniques across the spectrum.

Mark Lacy (*NRAO*)

The Spitzer Mid-Infrared Quasar Survey

Mid-infrared selection of AGN and quasars allows selection of samples μch less affected by dust obscuration than samples selected in the optical or

X-ray. In this talk, I will present results from the Spitzer mid-infrared selected quasar survey (SMIRQs). We have recently completed our campaign to obtain over 700 redshifts in the Spitzer SWIRE and XFLS fields of AGN and quasar candidates selected in the mid-infrared, using both our own spectroscopy and information in the literature. Our objects span a redshift range from 0 to 4.3. The nested sampling strategy means we span 1.5 orders of magnitude in AGN luminosity at z<2, allowing us to investigate trends with luminosity as well as with redshift. A preliminary analysis shows that dusty quasars are at least as common as unobscured quasars at all redshifts and luminosities (including the very highest), and may be even more common at z>~2. In combination with moderately deep imaging from the SERVS warm Spitzer Exploration Science program, we have also begun a comparative investigation of the environments of the dusty and unobscured quasars.

Jason L Melbourne (*Caltech*)
The Far-Infrared Properties of z=2 Dust Obscured Galaxies Revealed by Herschel SPIRE
We present the optical to far-infrared (FIR) spectral energy distributions (SEDs) of 100 z~2 ultra-luminous infrared galaxies (ULIRGs) selected to have extreme optical-to-MIR colors of R - [24] > 14. Objects selected in this way have been termed dust obscured galaxies (DOGs), and are among the most energetic galaxies observed. The large IR/optical flux ratio indicates high levels of dust heating by star formation and/or AGN activity, likely induced by recent mergers. 20% of the sample are detected at Herschel SPIRE 250 microns. DOGs with strong flux in the Herschel SPIRE bands tend to be among the most luminous of the sample at MIR wavelengths (e.g. at 24 microns), and thus have MIR/FIR flux ratios similar to local AGN hosting LIRGs and ULIRGs such as Mrk 231 and NGC 6240. None resemble the pure starburst Arp 220. We perform a stacking analysis on those galaxies not detected in the Herschel SPIRE bands to determine if these trends hold for the lower luminosity DOGs.

Desika Narayanan (*University of Arizona*)
The Efficiency of Star Formation in High-z Galaxies
An open question is whether merger-driven starburst galaxies at high-z form stars more efficiently than "quiescent" disks. Observationally, this measurement involves two key assumptions: (i) an assumption of what sort of galaxy at high-z is a merger, and what is a disk, and (ii), how to convert the observed CO molecular line luminosity into an underlying H2 gas mass. In this talk, I will discuss recent theoretical models which aim to answer both of these. In specific, I will present a model which aims to distinguish when a galaxy at high-z is a

merger, and when it is a disk. As an application of this model, I will present a merger-driven model for the formation of high-z Submillimeter Galaxies. I will then examine the CO-H2 conversion factor in galaxies, and present a methodology for observers to determine what numerical form of this factor to use in their observations. Utilizing these two models, I will show how presently available observational data suggest that mergers do indeed have a higher star formation efficiency than disks on average, though this is a function primarily of the star formation rate of galaxies.

Kai G Noeske (*STScI/ESA*)
Galaxy Star Formation Histories from the Mid- and Far-IR: The Blessings and the Blindspot
Scaling laws of galaxy star formation rates (SFR), like the SFR-stellar mass relation ("Galaxy Main Sequence"), allow to derive observational SF histories as a function of, e.g., galaxy mass, environmental density and morphology. They also provide support and new challenges to galaxy models and the understanding of SF physics. Current measurements of the Main Sequence still vary with the choice of SFR tracer and the related calibration and selection effects, and other SF scaling relations will be similarly affected. Rest-frame MIR/FIR data have become a cornerstone of SF history studies and are improving, with Herschel confirming and improving earlier results from Spitzer. However, I show that SFR based on the MIR/FIR alone, while successful for most massive galaxies, are not adequate to measure SFRs in all galaxies. FIR surveys are even blind to certain less massive galaxies with intense SF activity, hence introducing sample selection effects, mainly against objects that are crucial to understand the problem of inefficient SF in sub-L* galaxies at early times. I show how MIR/FIR data can be combined with other SFR tracers to obtain a more comprehensive view of SF and improve on disagreements of previous work.

Patrick M Ogle (*IPAC/Caltech*)
Accretion and Jet Power from Spitzer and WISE Radio Galaxy Surveys
Spitzer and WISE mid-IR observations are used to measure the dust-obscured bolometric luminosity in large samples of radio galaxies and type-2 quasars. WISE and 2MASS near-IR photometry of radio galaxies are used to estimate galaxy bulge and supermassive black hole masses. Putting these together, we estimate the accretion luminosity relative to the Eddington rate over 6 orders of magnitude in radio jet power. We find that radio-loud AGN are separated nicely into low-luminosity, mid-IR weak, low-ionization galaxies and high-luminosity, mid-IR luminous, high-ionization, hidden quasars. The break between the two types

occurs at 10^-3 times the Eddington rate, as predicted by accretion disk theory.

Sara M Petty (*UCLA*)
A WISE-GALEX Survey on the Nature of UV-excess in Nearby Early Type Galaxies
We analyze 50 nearby early type galaxies (ETGs) that have strong UV emission and have been observed by GALEX, SDSS, 2MASS and WISE. We use our new IR perspective with WISE to study massive, ETGs. The WISE colors are used to constrain the presence of dust or PAH emission, or to discern the presence of low level AGN across the red sequence. Of special interest are the properties of galaxies that fall in the green valley of the UV-optical color-magnitude diagram (CMD). We use the GALEX NUV, SDSS r, and the WISE 3.4, 4.6, and 12 micron photometry to define this color space. These galaxies have a mix of old and new star populations, exhibiting UV flux in excess (UVX) to that expected from traditional quiescent early types. Previous studies show the UVX does not evolve strongly with redshift ($0.05 < z < 0.65$) or environment. UV observations with FUSE and HUT indicate the source of the UVX is from extreme horizontal branch stars (EHBs). There is much debate whether the UVX is caused by the presence of the EHBs or recent star-formation. Our GALEX-WISE sample show traces of star-formation and that these galaxies are more than what their Hubble classification may indicate.

Naveen A Reddy (*NOAO*)
The Dust Properties of Typical Star-Forming Galaxies at High Redshift
I will review recent efforts to examine the dust attenuation and bolometric star formation rates of typical (L*) star-forming galaxies at redshifts z~2, using both Spitzer and Herschel data. I will discuss how dust affects our view of the UV/IR luminosity functions and focus on the trend between dustiness and redshift, and its implication for the chemical evolution of galaxies.

Huub Rottgering (*Leiden Observatory*)
LOFAR observations of starbursting galaxies
LOFAR, the Low Frequency Radio Array, is a pan-European radio telescope that is currently being commissioned. LOFAR has two types of antennas, one optimised for the 30 - 80 MHz range and one for the 110 - 240 MHz range. The antennas are grouped together in stations the size of soccer fields. The signals from the antennas will be digitised so that many beams on the sky can be formed. This makes LOFAR an extremely efficient instrument to survey large areas of sky. The Dutch part of the array will be finished in 2011 and will comprise 40 stations distributed over an area of diameter of 100 km.

This new observing facility has the potential to revolutionise our understanding of the star formation history of the Universe. The deepest fields, taking advantage of LOFAR's wide field of view, will allow us to detect radio emission from millions of normal star forming galaxies across the whole age of the Universe, but most importantly at the epoch when the bulk of galaxy formation occurred (1<z<3). There are a myriad of physical processes that likely influence the evolution of galaxies and their star-formation. Possibilities range from cosmic explosions in the early universe due to the formation of the first luminous quasars, variations in the density of the local environment, galaxy mergers and interactions, cosmological (quasi-) adiabatic accretion of gas, to instabilities in disks. Only wide area surveys that probe down to Milky Way rates of star formation can address the crucial need to understand how star formation proceeds as a function of epoch, galaxy mass and type and environment.

At this conference I plan to present the first results from LOFAR observations related to studies of star bursting galaxies. For a sample of a few hundred nearby galaxies the radio spectrum will have been mapped down to very low radio frequencies. In addition, the first observations of famous extragalactic fields that are currently being carried out will probe galaxies up to redshifts about one and will allow for a first study of the radio - IR correlation at low frequencies. Finally, we will show how the combination of LOFAR and Herschel surveys enable us to obtain samples of z>1 star-bursting galaxies that are so large that significant samples of proto-clusters of galaxies will be obtained. This will facilitate studies of how the physics of star formation differs between proto-clusters and the field.

Rachel S Somerville (*Rutgers University*)
What are IR-detected high-redshift galaxies and how well can we model them?
The physical nature of IR-detected high redshift galaxies, as well as their connection to populations discovered at other wavelengths, remains unclear. I will discuss how well cosmological semi-analytic models of galaxy formation with relatively simple prescriptions for describing the absorption and re-emission of dust are doing at reproducing the observed properties of galaxies from the far-UV to the FIR and over all currently observationally probed redshifts. I will also discuss what we know about the physical mechanisms that power IR-luminous galaxies at different epochs both from multi-wavelength observations and from theoretical models.

Daniel Stern (*JPL/Caltech*)
Mid-Infrared Selection of AGN with WISE
The Wide-field Infrared Survey Explorer (WISE) is an extremely capable and efficient black hole finder. We present a simple mid-infrared color criterion, W1-W2 > 0.8 (e.g., [3.4]-[4.6] > 0.8), which identifies 70 AGN candidates per square-degree. This implies a μch larger census of luminous AGN than found by typical wide-area optical surveys, attributable to the fact that mid-infrared selection identifies both unobscured (type 1) and obscured (type 2) AGN. Optical and soft X-ray surveys alone are highly biased towards only unobscured AGN, while this simple WISE selection likely identifies even heavily obscured, Compton-thick AGN. Using deep, public data in the COSMOS field, we explore the properties of WISE-selected AGN candidates. At the mid-infrared depths considered, 70 uJy at 3.4 microns and 160 uJy at 4.6 microns, this simple criterion identifies 80% of mid-infrared AGN candidates according to the criteria of Stern et al. (2005) with 80% reliability. We report on the demographics, μltiwavelength properties and redshift distribution of WISE-selected AGN candidates in the COSMOS field.

Sabrina Stierwalt (*Caltech/SSC*)
A Multi-Wavelength Look at Dust Properties of LIRGs in the GOALS Sample
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 mid- IR properties for the Great Observatories All-Sky LIRG Survey (GOALS) sample of 182 nearby LIRGs and 20 ULIRGs as derived from a multi-component spectral decomposition of low resolution spectroscopy from Spitzer IRS. The multi-wavelength survey allows for comparisons between MIR spectral features like PAH emission and silicate strength with other galaxy properties derived from IRAC, MIPS, HST, and GALEX imaging such as dust temperature, IR/UV excess (IRX), and merger stage. As a far IR-selected sample, GOALS probes deeply obscured nuclei not found in other PAH studies. Despite the large range of galaxy morphologies and spectral types, we observe a nearly uniform dust signature when the MIR emission is starburst- dominated. However, for sources with weak AGN, the PAH band ratios vary by as much as a factor of 5. We combine the results derived from our detailed fitting technique with data from other wavelengths to explore the cause of the scatter in these ratios as well as the differences in the dust characteristics (ionization state, grain size) for dusty versus unobscured LIRGs. We also trace the relative PAH emission and dust obscuration throughout the merging process.

Thomas A Targett (*Royal Observatory Edinburgh*)
The near-infrared properties of (sub)millimeter selected galaxies
We exploit new HST CANDELS data to determine the size and morphology of AzTEC and LABOCA selected galaxies in GOODS-South. In conjunction with the existing μlti-frequency data available in this field, we then perform SED fitting to obtain redshifts and stellar mass estimates.

Chao Tsai (*IPAC, Caltech*)
Local SFR Indicators in Nearby Galaxies Using WISE Bands
I present the results of star formation rate calibration in nearby galaxies using WISE data. We compares the star formation rates (SFR) indicated by the UV, H-alpha, and radio continuum, use the star formation regions in late-type galaxies that are resolved in the WISE 12" resolution. The results is generally consistent with the results in Calzetti et al. 2007 at similar wavelengths. We re-examine the local SFR density using the calibrated SFR estimate in WISE 12 and 22 micron bands. The contributions to the local SFRD from the major and minor galaxies in the local universe are discussed.

Krystal D Tyler (*Steward Observatory*)
The Nature of Star Formation at 24 microns in Cluster Abell 2029
High-density regions have long been known to affect the evolution of galaxies. Clusters house higher fractions of old, early-type galaxies and lower fractions of star-forming galaxies than the field, especially in their dense cores. While there have been many studies of star-forming galaxies in clusters at a variety of redshifts, few have been studied in detail in the IR down to low luminosities. As such, it is uncertain how dense regions affect smaller, lower star-forming galaxies or whether most clusters have similar effects on them. Using deep MIPS 24um observations of spectroscopically-identified members of a relatively-nearby cluster, Abell 2029, we plot the luminosity function of star-forming galaxies in the cluster and compare it to similar observations of the Coma cluster. We discovered the faint-end slope of the luminosity function is significantly different than Coma, lending uncertainties as to whether Coma is a "typical" cluster. We also unveiled a population of 24um-detected early-type galaxies with no obvious star formation or AGN activity, putting into question the use of IR observations as the sole indicator of star formation at low luminosities. Ultimately, we find that cluster galaxies of a variety of masses are all forming stars at similar levels, while field galaxies have a distinct mass-SFR relation where higher-mass galaxies are forming stars at higher rates. This behavior is driven by the larger

population in clusters of massive, early-type galaxies that are not forming stars rapidly, similar to our previous result for groups (Tyler et al. 2011) that the star formation is driven primarily by the mass/morphology of the individual galaxies, not by the environment.

Eelco Van Kampen (*ESO*)
Herschel-ATLAS/GAMA: Clustering of Sub-mm Galaxies at Low Redshifts
We have measured the clustering properties of low-redshift ($z < 0.3$) sub-mm galaxies detected at 250 micron in the SDP and Phase 1 fields which are part of the Herschel-ATLAS survey. We selected a sample for which we have high-quality spectroscopic redshifts, obtained from reliably matching the 250 micron sources to a complete (for $r < 19.4$) sample of galaxies from the GAMA database. We present both the angular and spatial clustering estimates for redshift slices in the range $0.05 < z < 0.3$.

Joaquin D Vieira (*Caltech*)
SPT surveys the millimeter sky
The South Pole Telescope (SPT) has conducted a survey to mJy depths over thousands of square degrees in the southern sky in the millimeter waveband. The aim of the survey is to constrain cosmological parameters through sensitive measurements of the cosmic microwave background (CMB) secondary anisotropies. I will present a general overview of the SPT project and discuss the latest results on the followup of lensed dusty objects, detection of massive galaxy clusters via the Sunyaev-Zeldovich effect (SZE), the CMB power spectrum, prospects for constraining the epoch of reionization and CMB lensing.

Lingyu Wang (*University of Sussex*)
An extended halo model of galaxy evolution: connecting stellar mass and star formation rate to dark matter halo
Combining the abundance and clustering properties of galaxies as a function of stellar mass from redshift z=0 to z=2, we build a statistical relation between the distribution of galaxies over stellar mass and the mass of the host dark matter halo (i.e. the conditional stellar mass function). This is possible thanks to large spectroscopic surveys of the local Universe (e.g. SDSS and 2dFGRS) as well as μlti-wavelength surveys of the high-redshift Universe (e.g. COSMOS, AEGIS). To further connect star formation rates in galaxies to the underlying dark matter halos, we use the observed relation between stellar mass and star formation rate in the same redshift range (z=[0,2]) to construct the two-dimensional probability distribution functions of galaxies as a function of stellar mass and star formation rate in halos of a given mass range.

Traditionally, estimation of the dust obscured star formation in the high-redshift Universe is difficult and often relies on the 24 micron data which result in large uncertainties in SFRs due to AGN contamination and SED variation. With the advent of Hershel, for the first time we are able to access to the peak of the infrared emission for large numbers of high-redshift dusty star-forming galaxies. Combined with the dark matter halo accretion history from N-body siμlations, we can naturally link different galaxy populations across cosmic time, i.e. identifying predecessors and descendants for different types of galaxies based on the evolution of the host dark matter halos. In addition, we can constrain the possible physical mechanisms (major merger, interaction, ram pressure stripping etc.) that trigger or quench star formation by studying the variation in the star formation activity as a function of halo mass and redshift. Direct comparison between this empirical halo model of galaxy evolution and semi-analytic models of galaxy formation and evolution is made and results are discussed.

Benjamin Weiner (*Steward Observatory*)
Infrared-luminous galaxies: their evolution, clustering, and fates
Infrared-luminous galaxies are powered by star formation or active galactic nuclei, but emit μch of their light as radiation reprocessed by dust into the far infrared. The most massive starbursts in both the local and high redshift universe manifest themselves as ultraluminous infrared galaxies, and it is commonly believed that ULIRGs are a stage in a merger sequence from ULIRG to optical QSO to ellipticals. However, it remains controversial to what degree ULIRGs and optical or X-ray AGN are the same objects at different times, what LIRGs and ULIRGs at z=1 are, and what they will evolve into. Are IR-luminous galaxies at high redshift mostly galaxy mergers, as they are at low redshift? Are ultraluminous IR galaxies strongly clustered, and can we infer whether they μst evolve into cluster galaxies today? With clustering studies, using a combination of Spitzer/MIPS surveys and the DEEP2 redshift survey, we can answer these questions. Since the evolution of clustering is well known, comparing clustering of ULIRGs, LIRGs, QSOs and optically selected galaxies constrains their masses and evolution. Our results suggest that the link between ULIRGs and QSOs is more complicated than a simple correspondence, and that ULIRGs and LIRGs are physically distinct populations at z=1. I will also discuss prospects for measurements with datasets such as the combination of WISE and BOSS, and with future large surveys.

Gillian Wilson (*UC Riverside*)
The Spitzer SpARCS z > 1 Cluster Survey

The 42 square degree SpARCS survey (PI Wilson) is the largest completed z > 1 cluster survey, and has discovered hundreds of new IR-selected clusters in the Spitzer SWIRE Legacy Fields. The SpARCS team has been putting huge effort into obtaining spectroscopic and μlti-wavelength (X-ray/optical/IR/Herschel/ALMA) follow up of the most interesting systems. I will show examples of recently confirmed high redshift clusters, and discuss what we are learning about galaxy evolution in the densest of environments from this unique wide-field IR survey.

Edward L Wright (*UCLA*)
WISE Overview
The Wide-field Infrared Survey Explorer (WISE) has mapped the entire sky in 4 infrared bands centers at 3.4, 4.6, 12 and 22 microns. I will give an overview of the WISE mission and its extragalactic results. At high galactic latitudes most of the sources detected by WISE are normal galaxies with modest star formation rates, seen in the light of old stars at 3.4 microns out to a redshift close to 1. Accreting black holes produce power law spectra that are significantly redder than the light of old stars. More active star forming galaxies appear strongly at 12 and 22 microns as dust absorbs the starlight seen at 3.4 and 4.6 microns and reradiates the energy at longer wavelengths, producing very red colors in the WISE bands for the most extreme starbursts.

Jingwen Wu (*JPL*)
Ground-based Submm/mm Follow-up Observations for WISE Selected Hyperluminous Galaxies
One of the major objectives of NASA's Wide-field Infrared Survey Explorer (WISE) mission is to search for the most luminous galaxies in the universe. The most productive method so far to select hyper luminous galaxies from WISE is to select targets that undetectable by WISE at 3.4 and 4.6 microns, while clearly detected at 12 and 22 microns, the so called W12 dropout galaxies. We have used the Caltech Submillimeter Observatory to follow-up WISE-selected high redshift (z=1.6-3.6) galaxies with SHARC-II at 350 to 850 microns, and BOLOCAM at 1.1 mm. Combining the Spitzer follow-up observations at 3.3 and 4.7 microns, WISE and CSO observations, we constructed the SEDs and estimate the infrared luminosities for these W12 dropout galaxies. The inferred infrared luminosities are at least 10^13 to 10^14 solar luminosities, making them one of the most luminous population ever known. The typical SEDs of these galaxies are flat from mid-IR to submillimeter, peaking at shorter wavelengths than other high-z mid-IR or submillimeter selected galaxies, leading to an averagely higher dust temperature than other populations. Their SEDs can not be well fitted with

any known type of galaxy templates, suggesting they may be a distinct population with extremely high luminosity and hot dust content. They may be extreme cases of Dust-Obsecured Galaxies (DOGs).

Lin Yan (*IPAC*)
Shedding Light on z~2 Spitzer ULIRGs with Herschel Far-IR SED and mid-IR Spectroscopy
I will present the results from a study which combines the Herschel SPIRE Far-IR observations with the Spitzer mid-IR spectra of a sample of 191 bright 24micron ULIRGs at z~0.3 -- 3.0. The combined data have shed new light on the nature of highly obscured, IR luminous AGN/QSO at z~2. We found that although mid-IR spectra and broad band photometry suggest that over 65%-75% of our sample have strong AGN contribution, the newly obtained Herschel SPIRE far-IR SED have shown surprisingly that only 19±10% of the sources are AGN-dominated (less than 1/3 of their power output is due to star-formation), 49±10% are starburst-dominated (less than 1/3 of their power output is due to AGN), and 31±3% are starburst-AGN composites. This high-lights the fact that many high-reddshift AGNs and QSOs could have clumpy dusty material which are undergoing starbursts. However, it is also possible that for some of the deeply embedded AGNs with deep silicate absorption features, their far-IR emission could be heated by photons from inner active galactic nuclei. In addition, we show that the 30-to-15micron colors of our sample are blue, similar to that of LIRGs in the local Universe, suggesting that it can not be used as a diagnostics for AGN, as opposed to the previous suggestions by some studies.

Jonas Zmuidzinas (*Caltech*)
Submillimeter Astronomy: What Happens Next
The launch of Herschel and the impending completion of ALMA are clear signals that the early, pioneering phase of submillimeter astronomy is over. Indeed, data pouring in from these projects will keep the field active and vibrant for years to come. However, the field is still quite young and scientific opportunities continue to emerge at an accelerating pace. As has been true since the beginning, detectors and instruments remain the central challenge for future progress. In this presentation, I will describe three lines of development being pursued at Caltech/JPL that aim to reshape the technology landscape: 1) very large, inexpensive imaging arrays; 2) miniature spectrometer chips for "3D" imaging of the universe; and 3) ultra-wideband low-noise submm amplifiers. The first two projects are aimed primarily at CCAT; the third may ultimately be most relevant for ALMA.


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