

Through the Infrared Looking Glass: A Dusty View of Galaxy and AGN Evolution



2-5 October 2011, Pasadena, CA

### **Posters:**

#### **Infrared Diagnostics of AGN and Starbursts**

#### 1. Philip Appleton (IPAC)

#### Shock-excitation of Green-Valley Galaxies in Hickson Compact Groups

Compact groups of galaxies represent density enhancements in the Universe comparable with clusters and are dominated by early type galaxies that lie in the "Green Valley" between the blue cloud and red sequence. Our observations of a sample of such groups has revealed that 10 percent of our IRS-Spitzer-observed group members show unusually powerful mid–IR H2 emission lines relative to PAH emission—suggesting shock—excitation. Most of these galaxies lie in the optical green valley, and exhibit specific star formation rates that lie between spirals and elliptical suggesting that they are a transition population in which shocks may play a role in their color evolution.

#### 2. Jonathan N Armour (Georgia Institute of Technology)

#### CO Line Emission from Nuclear Starburst Disks Around Active Galactic Nuclei

There is substantial evidence for a connection between star formation in the galactic nuclear region and the growth of central supermassive black holes. Furthermore, it has been posited that starburst activity in the re- gion around an active galactic nucleus (AGN) could be responsible for the obscuration required by the unified model of AGN. Therefore, we present predictions for the carbon monoxide (CO) line emission from nuclear star- burst disks around AGN. Nuclear starburst disk models are combined with a method for deriving the molecular mass fraction and a radiative transfer code, RATRAN, to predict CO line luminosities and fluxes for these objects. For the eighteen models examined, the average value for the J = 1  $\rightarrow$  0 line luminosity was found to be  $8.5 \times 10^8$  K km s<sup>-1</sup> pc<sup>2</sup>, while the average for the J = 2  $\rightarrow$  1 line luminosity was  $7.3 \times 10^8$  K km s<sup>-1</sup> pc<sup>2</sup>. These values are found to be in accord with measurements of ultra luminous infrared galaxies (ULIRGs) and quasar host galaxies. CO spectral line energy distributions (SLEDs) are also constructed for eighteen of the nuclear starburst disk models. The distributions are found to share many qualitative characteristics with those found for ULIRGs. Generally, those models in which a parsec- scale starburst models were found to have higher luminosities than those that failed to achieve such a state. Also, the CO SLEDs for starburst models were found to show more efficient excitation and higher brightness temper- ature ratios than those for models without a starburst. This finding allows for the possibility that CO SLEDs could be used to determine if starburst disks are responsible for the obscuration in many  $z \le 1$  AGN.

#### 3. Pedro Beirao (Spitzer Science Center - Caltech)

#### Heating and Cooling of the ISM in NGC 1097 with Herschel-PACS and Spitzer-IRS

NGC 1097 is a nearby Seyfert 1 galaxy with a bright circumnuclear starburst ring, a strong large-scale bar and an active nucleus. We present a detailed study of the spatial variation of the far-infrared [CII]158 $\mu$ m and [OI]63 $\mu$ m lines and mid-infrared H\_2 emission lines as tracers of gas cooling, and of the polycyclic aromatic hydrocarbon (PAH) bands as tracers of the photoelectric heating, using Herschel-PACS, and Spitzer-IRS infrared spectral maps. Examining how the gas heating efficiency varies due to the properties of the gas and dust, we focus on three regions in NGC 1097: the central region, where the nucleus and the ring are located, and two star forming regions at both ends of the bar. The ring has higher dust temperature and lower [CII]/PAH ratio than in the regions at the ends of the bar. The ratio ([CII][OI])/PAH is still lower in the ring than at the end of the bar, although with smaller difference, suggesting that the [OI] $\mu$ m line is a more important coolant in the ring. After subtracting the ionized gas component of the [CII] emission, from the ratio ([CII]+[OI])/PAH we calculated a gas heating efficiency in the ring of ~3.6% and ~5.7% in Enuc S. The starburst ring therefore has a lower gas heating efficiency than the ends of the bar. The average 11.3 $\mu$ m/7.7 $\mu$ m PAH ratio is lower in the ring than at the ends of the bar, but no correlation was seen between the 11.3 $\mu$ m/7.7 $\mu$ m PAH ratio and the [CII]/PAH ratio, implying that grain ionization is not the main influence on gas heating efficiency. The [CII]/FIR ratio is a factor of four lower in the ring, while the [OI]/FIR ratio is less suppressed in the

ring.Both the  $8\mu$ m/24 $\mu$ m ratio and the mass fraction of the PAH grains derived from SED modeling decrease in the ring relative to the spiral arms, suggesting that the contribution to gas heating of PAH grains decreases relative to larger grains. PDR models can reproduce well the [OI]/[CII] ratio and FUV heating is the most likely mechanism for H\_2 line emission in the nucleus and the ring, implying that shocks do not play an important role in gas heating. However, the H\_2 S(0)-S(3)/PAH (7.7 $\mu$ m) ratios in the nucleus are a factor of two above the ring average, suggesting that shocks can have a larger contribution to the H\_2 emission in the vicinity of the AGN.

#### 4. Torsten Boeker (European Space Agency)

#### Molecular gas around low-luminosity AGN in late-type spirals

I will present recent observations of the molecular gas in the vicinity of low-luminosity active galactic nuclei (AGN) in three bulge-less spiral galaxies: NGC 1042, NGC 4178, and NGC 4395. The presence of an AGN in the absence of a stellar spheroid provides an important boundary condition for theories of the co-evolution of supermassive black holes (SMBH) and galaxy bulges. Studying these objects therefore promises new insights into the long-standing question of how SMBH and galaxy bulge influence each other's growth. In all three galaxies, the (1-0) and (2-1) transitions of gaseous carbon monoxide (CO) are clearly detected within the central kpc. In the case of NGC 4395, this constitutes the first reported detection of CO. In general, the CO emission is faint, as may be expected from their less-than-spectacular star formation activity. Interestingly, however, both of the face-on galaxies in our sample (which allow an unimpeded view of their nucleus) show an elevated intensity ratio CO(2-1)/CO(1-0) when compared to late-type spirals without an AGN. I will discuss that this is unlikely due to a very compact CO source. Instead, it seems likely that even an energetically weak AGN can impact the physical state of the surrounding gas. This opens the possibility of using the CO line ratio as a new tool in the search for faint AGN that are otherwise very difficult to identify.

#### 5. Yu S Dai (Harvard-Smithsonian CfA)

#### A Population of Dust-Rich Quasars in the Lockman Hole

We report Herschel 250 micron detections of 36 quasars with redshifts between 0.5 and 3.6 from a MIPS 24 micron selected sample of 326 sources in the Lockman Hole. The extensive multi-wavelength data available in the field permit construction of the Spectral Energy Distributions (SEDs) from ultraviolet to the mid-infrared for all sources, and to the far-infrared (FIR) for the 36 sources. Quasars with Herschel FIR detections show dust temperatures in a range from 20K to 100K, and the total infrared luminosities from 10<sup>11.9</sup> to 10<sup>14.2</sup> solar luminosity, qualifying most of them as ultra- and hyper- luminous infrared galaxies. These FIR-detected quasars may represent a dust-rich population, but with lower redshifts and fainter luminosities than quasars observed in the submillimeter. The infrared quasar SEDs, peaking at 20 --100 micron, do not fit in the evolution picture proposed for PG quasars, where cold dust emission should occur before the naked quasar phase. The SEDs of FIR-detected quasars are very similar at shorter wavelengths (0.3--20 micron, rest-frame). These new far-infrared data show that the bolometric luminosities using the 5100 anstrom index may be underestimated for the dust-rich quasars.

#### 6. Aleks Diamond-Stanic (UC San Diego)

#### Probing Black Hole Growth and Star Formation with Mid-IR Spectroscopy

I'll present results regarding black hole accretion rates and star formation rates in galaxies hosting active galactic nuclei (AGNs). I'll use these results to identify biases in our census of black hole growth, to probe fundamental differences between obscured and unobscured AGNs, and to explore the connection between black hole growth and galaxy evolution. In particular, we find that the AGN luminosity (measured from the [O IV] 26 micron line) is strongly correlated with nuclear star formation (measured on sub-kpc scales using the 11.3 micron PAH feature), but only weakly correlated with extended star formation in the host galaxy (measured with 24 micron continuum emission). This suggests a physical connection between the gas on ~100 pc and sub-pc scales that is not related to external processes in the host galaxy.

#### 7. Tanio Diaz-Santos (SSC/Caltech)

#### The Spatial Extent of (U)LIRGs in The Mid-infrared: Nuclear and Extended Emission

We present results from our analysis of the extended mid-infrared (MIR) emission of the Great Observatories All-Sky LIRG Survey (GOALS) sample based on 5-14  $\mu$ m low-resolution spectra obtained with the Infrared Spectrograph on Spitzer. We calculate the fraction of extended emission as a function of wavelength for all galaxies in the sample, FEE $\lambda$ , defined as the fraction of the emission that originates outside of the unresolved central component of a source, and spatially separate the MIR spectrum of a galaxy into its nuclear and extended components. We find that the [Ne II]12.81  $\mu$ m emission line is as compact as the hot dust MIR continuum, while the polycyclic aromatic hydrocarbon (PAH) emission is more extended. the 6.2 and 7.7  $\mu$ m PAH emission is more compact than that of the 11.3  $\mu$ m PAH, which is consistent with the formers being enhanced in a more ionized medium. The presence of an AGN or a powerful nuclear starburst increases the compactness of the MIR continuum but has a negligible effect on the spatial extent of the PAH emission on kpc-scales. Globally, the 5-14  $\mu$ m spectra of the extended emission component are homogeneous for all galaxies in the GOALS sample, suggesting that the physical properties of star formation occurring at distances > 1.5 kpc from the nuclei of (U)LIRGs are very similar, resembling local star-forming galaxies with lower IR luminosities as well as star formation-dominated ULIRGs at z ~ 2. In contrast, the MIR spectra of the nuclear component of local ULIRGs and LIRGs are very diverse. These results imply that the observed variety of the integrated MIR properties of local (U)LIRGs arise, on average, only from the processes that are taking place in their cores.

#### 8. Andy D Goulding (Harvard-Smithsonian CfA)

#### The Evolution of AGN and their host galaxies at z~1 in wide-field multi-wavelength surveys

Galaxy properties (i.e., luminosity, color, morphology, star-formation history) and AGN activity are shown to evolve strongly with time. The redshift z~0.5--1.5 is a crucial epoch: (1) galaxies are evolving strongly as a function of stellar mass; (2) AGN activity is extremely prevalent; (3) massive clusters are forming and (4) the red sequence is becoming established. To unambiguously determine the dominant physical processes which are driving the growth and evolution of galaxies and their central black holes at z~1, requires sensitive µlti-wavelength wide-field surveys. We will present the incidence of AGN in a new study combining sensitive Spitzer IRAC infrared photometry, Chandra ACIS-I X-ray imaging, FIRST and NVSS radio data, and Keck/DEIMOS and MMTO/Hectospec optical spectroscopy in the combined ~4 deg^2 DEEP2 fields. Using this extensive suite of µlti-wavelength data, we have identified ~2500 of the ~20,000 DEEP2 galaxies at z~0.7--1.5 that have signatures of IR, X-ray and/or radio-bright AGN. Using this relatively large sample, we place new direct obscuration-independent constraints on the populations of AGN at z~1 and their host-galaxy properties. In particular, we highlight the importance of  $\mu$ Iti-wavelength techniques in order to build a complete sample of AGN. From X-ray stacking analyses of IR, radio and optically selected AGN, we additionally investigate the intrinsic properties of the AGN population which remains unidentified possibly due to heavy obscuration and/or host-galaxy contamination. Subsequently, we use these results to further our understanding of the AGN/host-galaxy connection at z~1.

#### 9. Kristen M Jones (University of Virginia)

#### Morphology and Star Formation Rates of 5 LIRGs at z~.01

Luminous Infrared Galaxies (LIRGs)—characterized by IR luminosities in excess of 10^11 solar luminosities—are ideal laboratories in which to study galaxy evolution. Their extreme luminosity has two proposed origins: AGN activity from accretion onto the system's central supermassive black hole, and high rates of star-formation which is unfortunately obscured by dust. Both of these processes can be driven by mergers and interactions, and as such LIRGs are particularly useful for investigating galactic environments over time. We study a sample of 5 LIRGs using the VLT's VISIR instrument. The high spatial resolution of the VLT allows us to investigate this activity in the nuclear region of these objects. The VISIR instrument's narrow band spectrometer allows us to study the 12.8 micron NeII line. Neon is produced primarily by high-mass stellar nucleosynthesis; singly-ionized neon will thus be found in emission shortly after the high-energy influence of further star formation and AGN activity. NeII thus serves as a tracer of very recent star formation. We find that on- and off-line images of our objects have similar structure and flux distribution. Four are centrally dominated point sources, with little diffuse structure detectable above the background. One of the objects we find to be a nuclear spiral, with more extended morphology. Similar star formation rates are expected for all of our objects, and we compare our results to overall star formation and morphology of the host galaxy.

#### 10. Toshihiro Kawaguchi (University of Tsukuba)

#### IR emission from AGN dusty tori: prospects for selection bias

The accretion disk and black hole in AGNs are surrounded by a dusty clumpy torus. We have developed a model for the Near-IR (NIR) emission and its time variability from the torus, taking into account the anisotropic illumination from the disk, the waning effect of each clump and the torus self-occultation (Kawaguchi & Mori 2010, 2011). We will present some results that would affect AGN surveys via rest-NIR emission. For instance, both a thick and thin tori display the weaker NIR emission. Objects with high Eddington ratios are also expected to be NIR weak. These indicate that NIR-selected AGNs tend to possess moderately thick tori (with the opening angle around 45deg) with sub-Eddington accretion rates. Moreover, a small inclination angle (closer to a face-on view) leads to a large rest-NIR variability.

#### 11. Mariana S Lazarova (University of California, Riverside) SEDs and mid-infrared spectral properties of LoBAL QSOs

We present Spitzer IRS spectra and MIPS photometry for a volume-limited sample of 22 SDSS-selected Low-ionization Broad Absorption Line QSOs (LoBALs) at 0.5 < z < 0.6. By comparing their mid-IR spectral properties and far-IR SEDs with those of a control sample of type-1 QSOs, we test the hypothesis that LoBALs are a transition phase from dust-embedded, ultraluminous infrared QSOs toward unobscured type-1 QSOs. The presence of current star-formation in the LoBAL host galaxies is inferred by the appearance of weak PAHs in one quarter of the IRS spectra. Silicate dust at 9.7 microns is exclusively seen in weak emission in half of the objects, a trend typical of type-1 QSOs. We model their SEDs and decouple the AGN and starburst contributions to the FIR luminosity. As many as 80% of the LoBALs have infrared luminosities comparable to those of type-1 QSOs. However, at least 20%, and as  $\mu$ ch as 60%, of the LoBALs reside in ULIRGs. The star formation rates (SFRs) corrected for AGN contribution to the FIR flux in most LoBALs are comparable to those found in type-1 QSOs. However, the ULIRG LoBALs have SFRs three times higher than the most star-forming type-1 QSOs. The median contribution of star formation to the total FIR flux in LoBALs is estimated to be 60%, while for type-1 QSOs we find 30%, in agreement with previous results for PG QSOs. Our results show that, while the majority of the LoBALs are similar to type-1 QSOs in terms of their mid- and far-infrared properties, at least some of the LoBALs are characterized by higher infrared luminosities and star formation rates. Statistical tests accounting for the preponderance of upper limits in the FIR fluxes show that the observed differences in the infrared luminosities of LoBALs and type-1 QSOs are statistically significant only at the 1-sigma confidence level, and it is possible that the two samples are drawn from the same parent population.

#### 12. Matt Malkan (UCLA)

#### Studying Dusty AGN Without X-rays

Several methods for finding dusty Seyfert galaxies and quasars do not require an X-ray detection. Most of them rely on the excess of near-IR continuum emitted from hot dust grains near the active nucleus. Good near-IR instruments can also pick out and diagnose Seyfert galaxies at substantial redshifts (z~1) from measurements of their strong emission lines. We discuss these methods with application to local 'validation' samples. We infer the fractions of the AGN population that are missed by various X-ray surveys.

#### 13. Paul Martini (Ohio State)

#### The Dust Dichotomy in Nearby Active and Inactive Early-Type Galaxies with Spitzer

Nearby, early-type galaxies that host Active Galactic Nuclei (AGN) are always observed to have dust lanes in the central kiloparsec in Hubble Space Telescope images. This stands in stark contrast to the absence of detectable dust in images of 75 percent of inactive, but otherwise identical, early-type galaxies. We have measured the dust masses for 45 early-type galaxies with Spitzer IRAC and MIPS photometry and found that the AGN hosts have over an order of magnitude more dust than the inactive sample. The spatial distribution of the dust seen at 8um with Spitzer also corresponds well to the dust lanes seen in absorption with HST. We discuss the properties of the dust seen in the active and inactive galaxies and the connection between the dust, its likely origin, and the fueling of AGN.

#### 14. Barbara L Medvar (*Creighton University*) Spitzer/IRS View of AGN Outflows

We present preliminary results of a study of the mid-infrared emission of broad absorption line (BAL) quasars to determine how they are related to the general population of quasars. We use the CLUMPY program code to create models of the tori that surround Active Galactic Nuclei. We compare these models to mid-infrared spectra of both BAL and non-BAL quasars obtained with the Spitzer Space Telescope. We specifically compare the inclination angle and the angular width of the torus for the two samples. We explore the physical meaning behind these results.

#### 15. Andreea O Petric (Caltech)

#### PACS and SPIRE photometry of PG QSOs

I will present PACS and SPIRE photometry which allows us to perform a systematic census of the cold ISM content of AGN hosts as a function of BH mass and accretion properties. Our sample is the most well studied sample of AGN: the PG QSOs.

#### 16. Andreea O Petric (Caltech)

#### Warm and Cold Molecular Gas in Luminous Infrared Galaxies

I will present an analysis of of 248 luminous infrared galaxies (LIRGs) nuclei which comprise the Great Observatories All-sky LIRG Survey (GOALS) observed with the Infrared Spectrograph on Spitzer in the rest-frame wavelength range between 5 and 38 microns.Warm H2 is detected in at least one transition in 40% of sources. I find that the H2 scales with aromatic band emission as seen in normal galaxies. The range of total H2 to IR ratios in LIRGs is wider than in ULIRGs but similar to normal galaxies (eg. Higdon et al. 2006, Roussel et al. 2007).I will also present 12 CO (1-0) high resolution (2 arcseconds) CO maps taken with the Combined Array for Research in Millimeter-Wave Astronomy of 10 LIRGs. We find a median mass of H2 of 2 x 1e10 Solar Masses, with media molecular gas surface densities of about 200 Solar Masses/pc^2. I will compare their morphologies to those of normal galaxies and ULIRGs.

#### 17. Wiphu Rujopakarn (University of Arizona)

#### The Structure of High-Redshift Star-Forming Galaxies: Implications on FIR SED and SFR

We present a finding that star-forming galaxies at both low and high redshifts fall into a nearly linear relationship between the infrared luminosity (LIR) and infrared luminosity surface density (LIRSD) over five orders of magnitude in luminosity, which indicates that high-redshift IR luminous star-forming galaxies have similar structures to local normal star-forming galaxies and primarily differ in the 100x to 1000x higher star formation rate (SFR) surface density. Together with our result that the LIRSD, instead of the LIR, is a good indicator of the shape of star-forming galaxies' spectral energy distribution at redshift 0 < z < 3, it is possible to predict the features of SEDs, including the mid-IR PAH emission complexes, and to use monochromatic 24 micron observations to estimate the LIR. We find that LIR can be determined just from 24 micron flux densities in agreement with those measured from µlti-band far-IR Herschel observations at on average within 0.1-dex, and with an rms scatter for

individual galaxies of only about 0.25 dex even at high redshift where the band are affected by PAH emissions. These results imply that a majority of high-redshift IR galaxies lie in the "main-sequence" of the star-forming galaxies and therefore that they generally have lower internal extinction than is typical for local counterparts of similar luminosity. We also present recent results from near- and mid-IR spectroscopy of gravitationally lensed star-forming galaxies at 1 < z < 3 using LBT/LUCIFER and Spitzer/IRS that we use to further study the extinction and structure in high-redshift star-forming galaxies.

#### 18. Deepak B Vaidya (ICCSIR)

#### Composite Dust in Active Galactic Nuclei

In the dense circumnuclear region around AGNs, porous composite dust is expected to be formed due to coagulation of small silicate and carbonaceous grains. Using discrete dipole approximation (DDA), we model the composite grains made up of a host silicate spheroid and inclusions of graphite/amorphous carbon/or voids. We calculate the absorption cross-sections of the composite grains in the spectral region  $5-25\mu$  and study the absorption as a function of the volume fraction of the inclusions and porosities. In particular, we study the effects of inclusions and porosities on 9.7 and 18 $\mu$  silicate features. Using the absorption efficiencies of the composite grains we compute the infra-red fluxes at several dust temperatures (100-300K) for a power-law grain size distribution. The model curves are then compared with the IR emission curves of a few typ1 AGNs, observed by Spitzer. We present the composite grain model and discuss the results.

#### **19. Irina B Vavilova** (*Main Astronomical Observatory NAS of Ukraine*) Properties of isolated AGNs at z < 0.05

We present the results of a study of the general properties of 62 isolated galaxies with active nuclei (isolated AGNs) at z<0.05. This sample was created to evaluate the influence of environment on the formation of accretion disk, radiation's characteristics, morphology and other AGN properties in comparison with those in groups. Due to the absence of the gravitational influence of neighbouring systems, the evolution of isolated galaxies is determined by initial conditions and physical processes occurring in these galaxies. However the main attention in studying AGNs is paid to the properties of active galaxy nucleus whereas AGN's environment, their host galaxy etc. are less investigated. To create the sample of isolated AGNs we used the Catalogue of Isolated Galaxies 2MIG by Karachentseva et al. (2010.), Catalogue of AGN by Veron-Cetty (2010) as well as databases NED and HYPERLEDA. In own turn, 2MIG Catalogue is based on the XSC 2MASS survey. The isolation criterion by Karachentseva, which was used for 2MIG Catalogue, is following: a galaxy with a standard angular diameter a1 is considered isolated if its angular separation X1i from all its neighbors with "significant" angular diameters ai (inside interval:  $4 \ge ai/a1 \ge 1/4$ ) is equal to or exceeds 20ai. The restrictions on stellar magnitude Ks is 4m

#### Multiwavelength Studies: Low to High-z Galaxies

#### 20. Peter D Barthel (Kapteyn Institute)

Radio galaxies, or infrared galaxies?

Herschel reveals prodigious starformation in powerful high redshift radio galaxies.

#### 21. Veronique Buat (Laboratoire d'Astrophysique de Marseille)

## <u>UV and far-IR emission of galaxies: new constraints on dust attenuation properties and star formation determinations at z~1.5</u>

The combination of far-IR and UV-optical rest-frame data has proved to be very efficient to measure the total star formation in galaxies and to quantify the amount of dust attenuation in galaxies. Using Herschel and ancillary data as part of the HerMES and GOODS-H key projects, we will show how dust attenuation and star formation rates can be properly determined. We will present the results of two recent analyses: Using stacking at 250 and 350 microns from Herschel/HerMES images of the COSMOS field we derive the mean IR-to-UV flux of UV rest-frame selected galaxies at z=1.5 and reconstruct the total IR luminosity function of our UV selected sample. We will use this function to discuss the amount of star formation seen or missed by a UV selection at z=1.5 We will also report on the detection and the measure of a UV bump at 2175 A in galaxies at redshift between 1 and 2 obtained by combining intermediate and broad band filters (MUSYC-Spitzer and Herschel data) in the CDFS in the framework of the GOODS-H project.

#### 22. James W Colbert (*Spitzer Science Center*) Extreme Silicate Absorbers in WISE

We present a sample of infrared-bright galaxies with extremely large 9.7 micron silicate absorptions selected from the WISE Preliminary Data Release catalogs. These highly obscured sources present a small but not well determined fraction of the whole ULIRG population, possibly representing one the earliest stages in the transition from star formation to black accretion domination, before the concealing gas and dust is expelled from the galaxy. We identify extreme silicate absorbers at two different redshift ranges, z=0.9-1.4 and z=0-0.4, depending into which filter W3 (12 micron) or W4 (22 micron) the silicate absorption feature falls. In order to minimize contamination by interlopers and better probe the physical properties of these

systems, we will combine the WISE selection with photometry from the UKIDSS near-infrared survey, as well as the Sloan Digital Sky Survey in the optical, to achieve an initial ~1000 square degrees of combined sky coverage.

#### 23. Alireza Farahmandi (*University of California, Riverside*) Dusty Star Formation in Clusters and in the Field at z < 0.5

We present a spectroscopic and photometric study of 104, Spitzer/MIPS 24micron selected galaxies in the fields of Spitzer First Look survey (FLS), XMM LSS and Lockman of SpARCS. We spectroscopically confirm 8 clusters of galaxies at 0.07 < z < 0.49 and investigate the nature of the cluster members (44 galaxies) and field galaxies (60 galaxies) and compare their dusty star formation activities. Spectroscopic classification of the galaxies shows different populations in clusters (54 / 22 / 6 / 12 % Star forming / Passive / Post-Starburst / AGN ) and in the field (66 / 5 / 2 / 28 %). In our sample, star forming galaxies in clusters have relatively high IR SFRs compared with star forming galaxies in the field, which have a larger range of IR SFRs. This is due to a selection bias. The SFR inferred from H\_alpha is lower for cluster galaxies than for field galaxies of the same IR-inferred SFR, suggesting that cluster galaxies may be dustier.

#### 24. Justin Howell (*IPAC*, *Caltech*) Diele Colorise in COALS and SINC

#### **Disk Galaxies in GOALS and SINGS**

Although the majority of nearby LIRGs show signs of tidal interactions or merger activity, approximately 20% are morphologically undisturbed disk galaxies. In contrast, surveys of LIRGs at intermediate redshift find approximately a 50%-50% split between apparently non-interacting disk galaxies and interacting/merging systems. In order to probe the nature of LIRGs that are not involved in major mergers, we compare Spitzer images and spectra of the 40 undisturbed disk galaxies in the Great Observatories All-sky LIRG Survey (GOALS) sample to the disk galaxies in the Spitzer Infrared Nearby Galaxies Survey (SINGS) which on average are more than an order of magnitude less luminous than LIRGs in the infrared. We report the results of an investigation of possible causes for the enhanced infrared luminosity in LIRG disks compared to the more quiescent disks in SINGS, including the influence of an AGN, specific star formation rate, extinction/dust content, and other parameters.

#### 25. Thomas Jarrett (Caltech/IPAC)

#### <u>Radio Continuum Observations of Hyper-Luminous Infrared Galaxies Discovered by the Wide-Field Infrared Survey</u> <u>Explorer</u>

We present radio continuum observations of candidate hyper-luminous infrared galaxies selected using WISE photometric colors. The observations were carried out using the Australia Telescope Compact Array (ATCA) and its new 2 GHz broadband back-end receiver (CABB). The science motivation is to (1) test whether the most luminous galaxies in the early universe are scaled-up starbursts (e.g., Arp220), or some combination of starburst with AGN (e.g., MRK 231), both of which would have profound consequences for our understanding of the evolution of the cosmic star formation rate, and (2) probe the energy production processes which are likely close to being at the Eddington limit. We find a high radio continuum detection rate, many of which exhibit jet-like resolved morphologies.

#### 26. Peter Kurczynski (Rutgers, The State University of New Jersey)

#### Estimating SFR from X-ray through radio: Which method works best at 1<z<3?

We determine Star Formation Rates (SFRs) in a sample of color selected, star forming (sBzK) galaxies (K(AB)<21.8) in the Extended Chandra Deep Field - South (ECDF-S). To avoid AGN, we eliminate 12% of the original sample that have X-ray detections in Chandra catalogs. Photometric redshift binned, average flux densities are measured with stacking analyses in Spitzer-MIPS IR, APEX/LABOCA submillimeter, VLA and GMRT radio and Chandra X-ray (including 4 Ms CDF-S) data. We include averages of aperture fluxes in MUSYC UBVRIz'JHK images to determine UV-through-radio Spectral Energy Distributions (SEDs). We determine total IR luminosities, compare SFR calibrations from FIR, 24 micron, UV, radio and X-ray wavebands, and we find preferred calibrations for each waveband. We find consistency with our best estimator, SFR(IR+UV), to within errors for dust corrected UV and the preferred radio SFR calibration. Our results show that 24 micron-only and X-ray SFR estimates should be used with caution. Average IR luminosities are consistent with Luminous Infrared Galaxies.

#### 27. Nicholas P Ross (LBNL)

#### The MIR properties of SDSS-III: BOSS Quasars

The bolometric energy output from quasars, e.g. v-L\_v has roughly equal power per decade, over the five decades from 100  $\hat{1}$ /4m to 10 keV, the Far/Mid-infrared through to the (hard) X-ray (e.g. Richards et al. 2006; Elvis et al. 2010). The SDSS-III: Baryon Oscillation Spectroscopic Survey (BOSS) is assembling an unprecedented sample of high, z>2, QSOs; 60,000 of which are already in hand. In this presentation, I will describe some initial studies into the properties of the SDSS and BOSS quasars using data from the WISE Preliminary Release Catalog, and what this can tell us about obscured and obscured luminous AGN activity.

#### 28. Yong Shi (IPAC/Caltech)

#### A synthesis of cosmic IR and X-ray background

We present a synthesis model of cosmic IR and X-ray background to study cosmic evolution of star formation (SF) and blackhole (BH) growth. By assuming that individual galaxies are experiencing both SF and BH accretion, our model decomposes the total IR LF into SF and BH components while taking into account the luminosity-dependent SED and its dispersion of the SF component, and the extinction-dependent SED of the BH component. The best-fit parameters are derived by fitting to the number counts and redshift distributions at X-ray including both hard and soft bands, and mid-IR to submm bands including IRAS, Spitzer, Herschel, SCUBA, Aztec and MAMBO. Based on the fit result, our models provide a series of predictions on galaxy evolution and black-hole growth. We found the total IR luminosity function is best described by evolution in both luminosity and density with the former monotonically increasing with redshift and the latter with the reverse trend. The same trend is preferred for the X-ray 2-10 keV LF. The cosmic IR light spectrum between 1-1000 um and the X-ray spectrum between 2-100 keV are well reproduced by the model. The cosmic IR-based SFR density rises sharply until z=1 and then drops slowly, while the cosmic IR-based black-hole accretion rate (BHAR) shows the exact same trend at z<1 with a factor of 50 offset in the normalization but continues slowly rising at z>1 to z=3. In terms of the number density, AGN are prominent in the IR/submm survey, with AGN number fraction around 30-40\% at f(24um) > 0.5 mJy and 50-80% at f(850um) > 3 mJy. The cosmic BHARs occur mainly in IR-normal galaxies at low-z but are hosted dominantly by LIRGs at z>0.7 and by ULIRGs at z>2.

#### 29. Hyunjin Shim (Spitzer Science Center)

#### Dissection of Halpha Emitters : Low-z Analogs of High-z Star-Forming Galaxies

Local analogs of strong Halpha emitters (HAEs) that dominate z-4 star-forming galaxies are identified using the Sloan Digital Sky Survey (SDSS) spectra. While more than 70% of the z~4 star-forming galaxies are classified as strong HAEs, only 0.04% of z<0.3 galaxies have Halpha equivalent widths (EW) larger than 500A, consistent with that of z~4 HAEs. Compared to local Lyman break galaxy analogs selected in UV, i.e., UV-luminous galaxies, local HAEs have bluer stellar continuum, stronger Halpha and [OIII] line, and weak [NII] line. Emission line analysis shows that local HAEs are not dominated by AGN, and local HAEs are relatively metal-poor galaxies with high gas temperature, close to Wolf-Rayet galaxies. WISE observation shows that significant fraction of local HAEs have higher infrared luminosity per unit UV slope beta, implying that the different extinction properties in these galaxies.

#### 30. Johannes G Staguhn (Johns Hopkins University & NASA/GSFC)

#### 2 Millimeter Ultra Deep Field Observations

The GISMO 2 mm bolometer camera at the IRAM 30m Telescope has demonstrated observational capabilities to obtain near confusion limited deep field observations in the 2mm band, with an angular resolution of ~ 16". Here we present a first look at the GISMO Deep Field (GDF).

#### 31. Ran Wang (NRAO)

#### Dust and molecular gas in redshift 6 quasar host galaxies

Observations of high-redshift quasars probe the growth of supermassive black holes and their connections to galaxy formation at the earliest epoch. We have been carrying out a systematic survey of the star formation and ISM properties in the host galaxies of  $z\sim6$  quasars using millimeter dust continuum and molecular CO emission. Strong dust continuum and CO (6-5) line emission has been detected in about 30% of them, indicating a few 10^8 Msun of 40 to 60 K warm dust and 10^10 Msun of highly-excited molecular gas in the quasar host galaxies. Spatially resolved molecular CO emission has been detected from one of the millimeter bright  $z\sim6$  quasars. The CO image suggests a gas-rich, major merging system with two intense star forming components, only one of which is in the active quasar phase. These results are consistent with the picture of intense host galaxy star formation co-eval with supermassive black hole (SMBH) accretion in the earliest quasar-host systems. We will expect further high-resolution (e.g. ALMA) imaging of the stellar, dust, and molecular gas components from these millimeter bright  $z\sim6$  quasars to fully probe the early growth of SMBHs and galaxies in the most distant universe.

#### **32.** Wei-hao Wang (*Academia Sinica Institute of Astronomy and Astrophysics*) <u>A New Extremely Red Color Selection for High-redshift Dusty Galaxies</u>

We present a new selection of extremely red galaxies (EROs) based on Ks and IRAC 4.5 um bands (KIEROs). Existing selections of EROs almost always pick up both dusty star forming galaxies and passively evolving galaxies. Our selection of KIEROs pushes the selection of EROs to the reddest possible wavebands. It is designed to avoid the 4000A Balmer breaks at z<4 (signature of passive galaxies), and therefore it primarily picks up very dusty galaxies. We found 196 KIEROs in the GOODS-N with Ks-4.5um > 1.6 (AB). They are at z > 1.5, mostly at z=2-4, similar to the redshifts of submillimeter selected dusty galaxies. However, KIEROs are less luminous than submillimeter galaxies in the IR, and therefore may represent the more "typical" members in the high-redshift dusty galaxy population. We do not find evidence for a significant sub-class of passive galaxies in the KIEROs, as expected from the color selection. In this talk, we will discuss this new color selection, and the star formation properties and AGN fraction of KIEROs.

#### **Infrared Surveys**

#### **33.** David G Elliott (*JPL*) Grid PRF photometry for WISE

Point sources in crowded fields observed by WISE can be detected and measured by fitting a grid of closely-spaced PRFs to overlapping single exposure images. Intermediate detection steps and final results are illustrated for a typical crowded field.

#### 34. Daniel P Gettings (University of Florida)

#### MaDCoWs: A WISE Search for the Most Massive High Redshift Galaxy Clusters

Because of its all-sky spatial coverage in the infrared wavelength regime, the WISE mission presents a unique resource for detecting massive galaxy clusters out to high redshifts. We describe the early stages of the Massive Distant Clusters of WISE (MaDCoWs) project, including details of the cluster detection method and preliminary results of our followup campaign.

#### 35. Ji hoon Kim (Seoul National University)

#### Dissecting Star Formation and AGN Activities through the Unexplored Window with AKARI

One of the most intriguing questions regarding black hole (BH)-galaxy coevolution picture is how the BH accretion, or AGN activity is linked to starburst activity. While it is suggested that AGN luminosity of quasars correlates with starburst luminosity (Schweitzer et al. 2006; Netzer et al. 2007; Maiolino et al. 2007; Lutz et al. 2007, 2008), it is unclear how AGN activity is connected to star formation activity for low luminosity AGNs. Although several studies based on ground-basd L-band slit spectra show a positive correlation between nuclear starburst activity and AGN activity in local Seyfert galaxies (Imanishi & Wada 2004; Watabe et al. 2008;Oi et al. 2011), these works rely on narrow slits on nuclear regions of targets probing only circumnuclear starburst activity and there are several theoretical studies opposing the positive correlation (Kawakatu & Umeµra 2004; Ballantyne 2008). Utilizing a unique slit-less spectroscopic capability of AKARI space telescope, we carried out three AKARI missions which provide clues to resolve this issue regarding star formation and nuclear activities of AGNs. Three missions, namely, AMUSES, ASCSG, and LQSONG, have different target selection criteria and scientific goals, but, as a whole, observe low redshift Seyferts and quasars, intermediate Seyferts at z ~ 0.36, and reverberation mapped AGNs using IRC spectrograph onboard AKARI space telescope, detect and measure the 3.3 micron PAH emission feature. We will present correlations of L(3.3) with nuclear activity probes, such as the monochromatic luminosity at rest-frame 5100Å (L(5100)), x-ray luminosity (Lx), and Eddington ratio based on host galaxy morphology. With the Seyfert sample at z ~ 0.36, we also provide clues for the evolution of such correlations.

#### 36. Itsuki Sakon (University of Tokyo)

#### AKARI Mid- to Far-Infrared observations of diffuse Galactic emission

We present the results of mid-infrared (MIR) spectroscopic observations of diffuse Galactic emission at various Galactic Longitudes on the inner and outer Galactic plane with Infrared Camera onboard AKARI. The variations in the UIR band ratios are examined in terms of the radiation environments which are gathered from the far-infrared (50-170micron) spectral energy distribution (SED) obtained by AKARI/FIS at each position of the MIR slit for spectroscopy. We found that the 6-9micron features / 11.2micron in the inner Galactic plane are typically higher than those in the outer Galactic plane. We interpret this results by the larger contribution of PAHs powered by harsh radiation fields associated with massive star clusters in the inner Galactic plane. We also examine the mid-infrared spectral characteristics of UIR features in the mid-infrared and the SED in the far-infrared obtained at an off-plane position (lbetal=~2.5deg) and compare them with those of on-plane positions.

#### 37. Aleksandra Solarz (Nagoya University)

#### Infrared star/galaxy separation in AKARI NEP Deep field

It is crucial to develop a method to classify objects detected in deep infrared surveys. In particular, a method to separate galaxies from stars using only the infrared information is necessary to study the properties of galaxies, e.g., to estimate the angular correlation function, without introducing any additional bias. We aim to separate stars and galaxies in the data from the AKARI North Ecliptic Pole (NEP) Deep survey collected through nine AKARI / IRC bands from 2 to 24 m, that cover the near- and mid-infrared wavelengths (hereafter NIR and MIR, respectively). Since the sources detected in the surveys vary from Galactic objects to distant galaxies and quasars, AKARI data have to be categorized based on the photometric data and optical surveys data. The main objective behind this research is to select samples of NIR and MIR galaxies by means of the developed methods and use them for estimating the correlation function for these type of objects. To this end we have constructed NIR and MIR colour-colour (CC) diagrams, measured the stellarity parameter and elongation of all objects. Combining all three factors resulted in obtaining methods for this classification in NIR and MIR separately. As a confirmation of developed methods we have incorporated auxiliary optical data obtained by Subaru telescope, identification of observed sources in the NED and SIMBAD databases and Euclidean normalised number count plots. Relying on the public optical databases, detected sources were cross-matched, only to find that 2% of detected sources had previously known optical counterparts. Nevertheless,

the source counts and comparison with the auxiliary optical data from Subaru telescope (showing consistency up to 73% for MIR), prove our star/galaxy separation methods to be reliable. With the obtained separation methods we are have selected a sample of MIR galaxies which we use to compute the correlation function. We are planning on publishing these results in the near future.

#### 38. Harry I Teplitz (IPAC)

#### Science Validation of the Spitzer Source List

The Spitzer Science Center will produce new mosaics and a source list (SL) of photometry for a large subset of imaging data in the Spitzer Heritage Archive (SHA). The list will enable a large range of science projects. The primary requirement on the SL is very high reliability, and secondarily areal coverage, completeness and limiting depth. The SHA at the NASA Infrared Science Archive (IRSA) will serve the mosaics and SL as an enhanced data product. The SL will include data from the four channels of IRAC (3-8 microns) and the 24 micron channel of MIPS. The Source List will include image products (mosaics) and photometric data for Spitzer observations of about 1500 square degrees and include around 30 million sources. We anticipate a preliminary data release at the end of 2011, and a final data release in fall of 2012. In this poster, we describe ongoing science validation of the Spitzer Source List, and discuss the range of use cases which will be supported.

#### 39. Yoshiki Toba (Soukendai, ISAS/JAXA)

#### The Mid-Infrared Luminosity Function of Galaxies using AKARI midinfrared All-Sky Survey Catalogue

We present the first determination of the 18 micron luminosity function (LF) of galaxies at 0.006 < z < 0.7 (the average redshift is ~0.04) using the AKARI mid-infrared All-Sky Survey catalogue. We have selected a 18 micron flux-limited sample of 243 galaxies from the catalogue in the SDSS spectroscopic Legacy region. We then have classified sample into four types; Seyfert 1 galaxies (including QSOs), Seyfert 2 galaxies, LINERs and Star Forming galaxies using mainly [OIII]/H\_beta vs. [NII]/H\_alpha line ratios obtained from the SDSS. As a result of constructing type I AGNs and type II AGNs LFs, we found following results; (i) the number ratio of type II AGNs to type I AGNs is 2.30-0.84 obtained from type I and type II LFs, that value is large than the results obtained from optical LFs. (ii) the fraction of type II AGNs in the entire AGNs may be anticorrelated with 18 micron luminosity.These results suggest that the torus structure depends on the mid-infrared luminosity of AGNs and most of the AGNs in the local Universe are obscured by dust.

#### **Modeling and Measuring Evolution**

#### 40. Michael Brown (Monash University)

#### Fifty Galaxy SEDs Spanning from the UV to the IR

Spectral templates are essential for studies of distant galaxies, enabling the physical properties of galaxies to be derived from observables. This includes luminosities utilizing k-corrections and photometric redshifts determined by fitting template spectra to photometry. Many commonly used galaxy spectral templates have large errors, in some cases on the order of tens of percent. These errors propagate through to the resulting science, including measures of galaxy stellar populations and estimates of galaxy mass assembly. We present 50 new galaxy spectral templates, derived Bok optical spectra, Spitzer IRS spectra, AKARI spectra and k-correct models. These spectra have been constrained and verified with matched aperture photometry stretching from the UV to the mid-IR. We demonstrate how these templates can be used to significantly improve the science derived from the current generation of galaxy imaging and spectroscopic surveys.

#### 41. Andrew J DeGroot (UC Riverside)

#### **Evolution of Color Luminsosity Function in Galaxy Cluster since z~1.5**

We present the evolution of the color luminosity (z'-IRAC ch1 color) for galaxy cluster members since since  $z\sim1.5$ . We study the evolution as a function of redshift and richness for six cluster fields comprising ~42deg^2.

#### 42. Daniel J Hanish (IPAC)

#### Infrared Quasar SED Templates from the SAFIRES Archival Survey

The spectral energy distributions of QSOs have been examined in the past, but only in statistically limited samples. The previous work of Polletta et al.(2007) generated the most complete set of quasar SED templates to date, but its sample consisted of only 30 SWIRE AGNs possessing a full complement of radio, infrared, and optical data. We expand on this method using the Spitzer Archival Far-IR Extragalactic Survey (SAFIRES), a project adding hundreds of thousands of MIPS 70um and 160um detections to the archival Spitzer Source List's IRAC and MIPS 24um sources. Matching the SAFIRES µltiwavelength source lists to the SDSS quasar catalogs enables us to generate a series of SED templates extending into the far-infrared, using a robust sample containing thousands of QSOs across approximately 600 square degrees of the extragalactic sky.

#### 43. Anya H Kwan (San Marino High School)

#### WISE Large Galaxy Atlas

The web-accessible database was designed to aid the WISE team determine which galaxies with WISE infrared images should be built with high-resolution image reconstruction as part of the WISE Large Galaxy Atlas. It consists of the largest angularsized galaxies as catalogued in the NASA Extragalactic Database (NED) from primarily 2MASS, SDSS and RC3 diameters. The user is able to traul through the database using either size or galaxy name. In addition to the optical/NIR diameter and µltiple variants on the source name, information includes postage-stamp images, coordinates, morphology, axis ratio, redshift, extinction and miscellaneous notes. There are active links to the NED entry for the source, and most importantly, to the WISE image database curated by the Infrared Science Archive (IRSA).

#### 44. Sean E Lake (UCLA Dept. of Physics & Astronomy)

#### **Optical Spectroscopic Survey of High Latitude WISE Selected Sources**

We report on the results of an optical spectroscopic survey at high Galactic latitude ( $|b| \ge 30 \text{ degs}$ ) of a sample of WISE-selected targets, grouped by WISE W1 ( $\lambda_{eff} = 3.4 \text{ micron}$ ) flux, which we use to characterize the sources WISE detected. We observed 762 targets in 10 disjoint fields centered on ultra-luminous infrared galaxy (ULIRG) candidates using the DEIMOS spectrograph on Keck II. We find  $0.30 \pm 0.02$  galaxies arcmin<sup>-2</sup> with a median redshift of z=0.33\pm0.01 for the sample with W1  $\ge 120 \text{ microJy}$ . The stellar population in our survey have densities from  $0.23 \pm 0.07 \text{ arcmin}^{-2}$  to  $1.1 \pm 0.1 \text{ arcmin}^{-2}$  for the same sample. We measured good spectra for  $\ge 90\%$  of our targets for sources with W1 flux  $\ge 120 \text{ microJy}$  that also had i-band flux  $\ge 18 \text{ microJy}$ . For targeting we used very preliminary data reductions available to the team in August of 2010, and so our results present a conservative estimate of what is possible to achieve using WISE's Preliminary Data Release for the study of field galaxies.

#### 45. Juan Rafael Martinez-Galarza (Leiden Observatory)

#### Beyond the evident: A New Bayesian Tool for Multiwavelength SED fitting of Starbursts

The UV to submillimeter Spectral Energy Distributions (SEDs) of star-forming regions and starburst galaxies are unique tracers of the star formation processes in these environments, since they contain information on the escaping and processed photons initially emitted by newly formed massive stars. We present a novel fitting routine based on Bayesian inference that finds robust best fits to the mid-infrared spectra of starbursts from a grid of state-of-the-art panchromatic SED models, and provides statistically meaningful constrains to model parameters such as starburst age, fraction of photon-dominated regions to HII regions and star formation rates. By applying this fitting routine to the test cases 30 Doradus and NGC 604, we show that the inclusion of the fine-structure emission lines in the fitting is crucial to break the degeneracies between model parameters, and emphasize the importance of far-infrared measurements to further constrain the models. As an outlook, we show that our calibrated fitting routine is an excellent tool in the analysis of the spectral properties of unresolved starbursts.

#### 46. Raanan Nordon (MPE)

#### PEP: The redshift evolution of mid-to-far IR SED of distant galaxies

In this talk we present our results and interpretations for the redshift evolution of star forming galaxies as reflected in their IR SEDs. We use Herschel-PACS deep far-infrared imaging of the GOODS fields from the PEP project, as well as Spitzer photometry and spectroscopy to study the rest frame 6 to 90 um infrared SEDs of galaxies between 0.7 < z < 2.5. We find that galaxies which lie parallel to the main-sequence of star-forming galaxies tend to have similar IR SEDs and in particular, rest-frame 8um luminosity relative to total IR luminosity. The SEDs evolve with increasing distance from the main-sequence in a similar way at all studied redshifts. Previous findings of mid-IR excess that leads to over-estimation of SFRs at  $z\sim2$  are explained by this redshift evolution with the main-sequence. No significant MIR emission from obscured AGNs is required to explain the typical emission around 8 um of most 0.7 < z < 2.5 star forming galaxies. We provide calibrations for SED libraries by distance from the main-sequence, as well as by LIR to be used in cases where the mass is not well determined. The results are verified with a sample of ultra-deep IRS spectroscopy. In light of our results and other recent studies, we will briefly discuss our interpretations on the structure of star-forming galaxies in high-redshifts, on and off the main-sequence.

#### 47. Andreea O Petric (*Caltech*) SED of high redshift MIR selected AGN

I will present 450 optical to FIR SEDs of MIR selected AGN at z>1.5. Here we use the clumpy torus models, most recent stellar population models, as well as a template for M82 to estimate the contribution of the AGN, old stars and current star-formation to the bolometric luminosity. I will compare those contributions as a function of redshift and AGN type.

#### 48. Yong Shi (IPAC/Caltech)

#### A synthesis of cosmic IR and X-ray background

We present a synthesis model of cosmic IR and X-ray background to study cosmic evolution of star formation (SF) and blackhole (BH) growth. By assuming that individual galaxies are experiencing both SF and BH accretion, our model decomposes the total IR LF into SF and BH components while taking into account the luminosity-dependent SED and its dispersion of the SF component, and the extinction-dependent SED of the BH component. The best-fit parameters are derived by fitting to the number counts and redshift distributions at X-ray including both hard and soft bands, and mid-IR to submm bands including IRAS, Spitzer, Herschel, SCUBA, Aztec and MAMBO. Based on the fit result, our models provide a series of predictions on galaxy evolution and black-hole growth. We found the total IR luminosity function is best described by evolution in both luminosity and density with the former monotonically increasing with redshift and the latter with the reverse trend. The same trend is preferred for the X-ray 2-10 keV LF. The cosmic IR light spectrum between 1-1000 um and the X-ray spectrum between 2-100 keV are well reproduced by the model. The cosmic IR-based SFR density rises sharply until z=1 and then drops slowly, while the cosmic IR-based black-hole accretion rate (BHAR) shows the exact same trend at z<1 with a factor of 50 offset in the normalization but continues slowly rising at z>1 to z=3. In terms of the number density, AGN are prominent in the IR/submm survey, with AGN number fraction around 30-40\% at f(24um) > 0.5 mJy and 50-80% at f(850um) > 3 mJy. The cosmic BHARs occur mainly in IR-normal galaxies at low-z but are hosted dominantly by LIRGs at z>0.7 and by ULIRGs at z>2.

#### 49. Fangting Yuan (Nagoya University, Japan)

# Star Formation Rates and Stellar Masses Calibrations using WISE luminosities: A Theoretical Study with FUV to IR Data by CIGALE

The Wide-field Infrared Survey Explorer (WISE) provides all sky mid-infrared data with extremely high sensitivity and resolution, thus an unprecedented chance to study the star formation and galaxy evolution in the Universe. Star formation rates (SFRs) and stellar masses are basic qualities of galaxies; therefore, calibrations of WISE filters into SFRs and stellar masses are important to give a direct view on galaxy properties by WISE data. Start from an infrared selected GALEX-SDSS-2MASS-AKARI sample of local star forming galaxies, we construct template spectra with the SED fitting method CIGALE. Using these templates, we build mock samples from redshift 0 to 3, which the redshift limit of WISE for ULIRGs. We then study the correlations of the WISE luminosities with total infrared luminosities, SFRs and stellar mass, and present calibrations of SFRs and stellar masses using these luminosities. In order to examine the evolution of the SED templates and the effect on the SFR and stellar mass calibrations, we compare the mock samples with higher redshift samples in the COSMOS field. A combination of WISE luminosities and UV luminosities as SFR indicators are also investigated to explore the evolution of dust properties. We find W3 and W4 fluxes can indicate SFRs using a simple log-log form with little scatters when the restframe wavelengths are longer than about 6 um. When wavelengths become shorter, the observed luminosities are more connect to the emission of old stellar populations rather than dust, therefore lose the reliability to trace SFRs and become correlated with stellar masses. W1 and W2 filters have shorter wavelength and can reflect stellar masses from low to high redshifts. The calibrations present here help convert WISE luminosities into SFRs and stellar masses, therefore will shed new light on the study of the evolution of galaxies.

#### Future Opportunities for Extragalactic Science in the Infrared

#### 50. Eric Becklin (UCLA/USRA)

#### SOFIA: Status and ExtraGalactic Potential

The joint U.S. and German Stratospheric Observatory for Infrared Astronomy (SOFIA), to develop and operate a 2.5-meter infrared airborne telescope in a Boeing 747SP, has obtained first science with the FORCAST camera in the 5 to 40 micron spectral region and with the GREAT Heterodyne Spectrometer working in the 100 to 240 micron spectral region. Results with both instruments have been obtained and will be discussed, with emphasis on extra-galactic studies Future observing opportunities and participation in future instrument developments, on the 20 year lifetime of the observatory will also be discussed.

#### 51. Matt Bradford (JPL/Caltech)

#### The Background-Limited Infrared Submillimeter Spectrograph (BLISS) for SPICA

The far-IR waveband carries half of the photon energy ever produced in galaxies and quasars, evidence of the major role of dust-obscured processes in galaxy evolution in the first half of the Universe's history (z>1). We are developing the Background-Limited Infrared-Submillimeter Spectrograph (BLISS) to capitalize on SPICA's cold telescope and provide a breakthrough far-IR spectroscopy capability. BLISS-SPICA is 6 orders of magnitude faster than the spectrometers on Herschel and SOFIA in obtaining full-band spectra, and offer the capability to overcome the spatial confusion limit with spectroscopic capability. BLISS-SPICA will observe dust-obscured galaxies at all epochs back to the first billion years after the Big Bang (redshift 6), thereby probing the complete history of dust-obscured star formation and black-hole growth. It will also be extremely powerful for studying ice-giant planet formation in protoplanetary disks, with its sensitivity to very small amounts of gas.

Given its enormous potential, BLISS has been recommended by Astro2010 as an example US contribution to SPICA. BLISS covers the 38-433 micron range in six grating-spectrometer bands, with two simultaneous sky positions. The baseline detector package is 4224 silicon-nitride micro-mesh leg-isolated bolometers with superconducting transition-edge-sensed (TES)

thermistors, read out with a cryogenic time-domain multiplexer. All spectrometers and detector arrays are cooled to 50mK for optimal sensitivity. All technical elements of BLISS have heritage in mature scientific instruments, and many have flown. We present the science case for BLISS, as well as our progress in the key technical aspects: 1) detector and readout performance demonstration, 2) opto-mechanical instrument configuration, and 3) sub-K cooling and cryogenic system approach.

#### 52. Jane R Rigby (*NASA Goddard*) Active Galactic Nuclei with JWST

I'll discuss several ways in which JWST will probe the cosmic history of accretion onto supermassive black holes, and the coevolution of host galaxies. Key investigations include: 1) Measurements of redshift, luminosity, and AGN fraction for obscured AGN candidates identified by other missions. 2) Measurements of AGN hosts at all redshifts, including stellar masses, morphology, interactions, and star formation rates. 3) Measurements of stellar mass and black hole mass in AGN at high redshift, to chart the early history of black hole and galaxy growth.

# 53. Takehiko Wada (ISAS/JAXA)SPICA: mission over view and the latest statusMission over view and the latest status of the SPICA project will be shown.

#### **Unregistered Posters**

#### 54. Carol Lonsdale (NRAO)

#### Feedback from the Most Luminous Dust-Obscured AGN in the Universe

AGN-powered feedback of energy and momentum via radiation pressure ("quasar mode") on interstellar dust and via jet momentum ("radio mode") from a supermassive black hole (BH) into its host galaxy regulates the evolution of both the BH and the galaxy. Feedback is likely to be strongest in the most luminous dust-obscured QSOs, particularly those containing radio sources too luminous to be powered by starbursts. We have selected a unique sample of 254 of the most luminous obscured QSOs in the universe by indentifying strong mid-infrared sources from the WISE survey having (1) convex mid-infrared spectra and (2) bright NVSS radio counterparts. We are pursuing a multi-telescope follow-up program to understand the physical and evolutionary nature of these extreme feedback candidates, including spectroscopy, ALMA and EVLA.

#### 55. Lei Hao (Shanghai Astronomical Observatory)

#### AGN Extinction from Optical and Mid-IR Spectroscopic Studies

Many of our knowledge on galaxy formation and evolution so far are obtained from galaxy optical spectra. At the Spitzer era, we are able to obtain abundant information such as the extinction, star formation, ionization, and metal abundances of galaxies from their mid-IR spectra. How are they compared, and is there a more complete picture of galaxy evolution by combining the optical and mid-IR spectroscopic observations? Here, we present an ongoing studies of connecting the optical and mid-IR spectra of galaxies. We cross-march all galaxies in the SDSS DR7 main galaxy spectroscopic catalog and the Spitzer IRS archive catalog. We found 755 galaxies with < 1 arcsec matching distances. We make all sorts of measurements, such as the optical emission line strengths, star-formation rates, metallicity, and the mid-IR silicate strengths, and PAH features. There are many sciences we would like to pursue with this sample and we show the preliminary results on some of them.

## 56. Noah Brosch (*Tel Aviv University*)

#### Dust and Gas in E/SO Galaxies

How do E/SO galaxies acquire their interstellar medium (ISM)? What is the role of the ISM in the evolution of these galaxies? Hoag's object, N2685, and AM 1934-563 are examples of and entire class of early- type objects containing dust and sometimes ionized gas (ISM). In many cases, the ISM is kinamatically decoupled from the main galaxy body. These cases include the polar-ring galaxies. How is the ISM accreted? What is its origin?

