Cosmic Dawns: ALMA Early Science Commences

Tuesday, 8 January 2013 2:00pm-3:30pm
Chair: Alwyn Wootten

1. Colette Salyk 2:00pm-2:18pm
2. Daniel Marrone 2:18pm-2:36pm
3. Nicholas Scoville 2:36pm-2:54pm
4. Ran Wang 2:54pm-3:12pm
5. F. Walter 3:12pm-3:19pm
6. J. Hodge 3:19pm-3:26pm

Invited Oral Abstract #1
Presenter: Colette Salyk
NOAO, Tucson, Arizona
Title: CO 2-1 images of protoplanetary disk winds
Abstract: The process of star and planet formation is often envisioned as a series of discrete evolutionary stages (0–III) during which a core collapses (0), forms a disk and outflow (I), clears its envelope and reveals an optically thick protoplanetary disk (II) and, finally clears the disk, retaining only planets and second-generation dust (III). Objects in transition between two consecutive stages should also exist, and can provide particular insight into disk evolution. Recently, a new class of protoplanetary disk has emerged as a possible link between stages I and II, in which the envelope is largely dissipated, but where the disks produce significant low-velocity molecular outflows or winds. These so-called disk wind sources were first identified by the presence of strong IR molecular line emission, with spectrally-resolved line profiles too centrally-peaked to be fit by a protoplanetary disk alone. Here, we will present the exciting results of a search for a millimeter-wavelength counterpart to the IR-discovered molecular disk winds in a canonical disk wind source. We will also discuss the implications of these results for disk mixing, system evolution and any forming protoplanets.

Invited Oral Abstract #2
Presenter: Daniel Marrone
University of Arizona
Title: ALMA Observations of the Brightest Starbursts in the Universe
Abstract: The study of high-redshift galaxies, especially those that are optically faint but actively forming stars, is a key motivation for ALMA. Nevertheless, these objects will be faint targets even for the completed array. A more detailed view of distant galaxies is possible through gravitational lensing, which can magnify their luminosity by an order of magnitude or more. We have used ALMA to investigate a large sample of lensed, dusty, starburst galaxies discovered by the South Pole Telescope in a 2500 square degree map of the extragalactic millimeter sky. ALMA imaging confirms that these sources, the brightest high-redshift, dusty sources in the sky, are indeed lensed by foreground galaxies into spectacular arcs and rings. Moreover, a blind redshift search for 26 sources using the ALMA 3mm receivers demonstrates that this sample includes many of the most distant submillimeter galaxies known, with an unprecedented fraction found at $z>4$. These results were all obtained from just minutes

of integration per source, demonstrating the power of this new facility to dissect these sources in future, longer integrations.

Invited Oral Abstract #3
Presenter: Nicholas Scoville
Caltech
Title: Measuring The ISM in High Redshift Galaxies
Abstract: The Masses of ISM in High Redshift Galaxies are a major determinant of their evolutionary state, star formation activity and how they will evolve to low redshift. Measurement of the CO lines at z > 0.5 are time consuming even with ALMA sensitivity and the derived ISM masses are subject to uncertainty in the CO-to-H2 conversion factor. Here I describe a
much faster technique -- measuring the long wavelength Rayleigh-Jeans dust emission using the spectacular continuum sensitivity of ALMA and the using an assumed (metallicity dependent gas-to-dust abundance ratio from low-z galaxies) to infer an ISM gas mass. Initial results from ALMA Cycle0 are presented for a sample of stellar mass selected galaxies in COSMOS. This technique will enable measurement of 100's of galaxies at high-z with observations of typically ~10 min per galaxy.

Invited Oral Abstract #4
Presenter: Ran Wang
University of Arizona
Title: [C II] Line Emission and Star Formation from Quasar Host Galaxies at z~6
Abstract: Huge amounts of far-infrared (FIR) emitting warm dust and molecular gas have been discovered in the host galaxies of ~30% of the quasars at z~6, indicating the presence of massive star formation coeval with rapid supermassive black hole (SMBH) accretion in these earliest quasar host galaxies close to end of cosmic reionization. We present our recent ALMA observations of the [C II] 158 micron fine structure line emission from the host galaxies of four millimeter bright quasars at z~6. The detections of [C II] line emission provide strong evidence of active star formation and SMBH-galaxy coevolution in the most distant universe. The line velocity maps of three of them at ~0.6" spatial resolution show indications of velocity gradient along the major axis direction, which suggests the presence of a nuclear star-forming disk over the central a few kpc region of the quasar hosts. These results reveal important constraints on the distributions of nuclear star formation and dynamical properties of the cool atomic gas in the young quasar host galaxies. They are the keys to understand the growth of the first SMBHs and their host galaxies close to the cosmic reionization epoch.

Contributed Oral Abstract #5
Title: ALMA Observations of NGC 253 Reveal a Molecular Outflow and Resolve the GMCs that Fuel the Nuclear Starburst Activity
Authors: Fabian Walter[1], Alberto D. Bolatto[2], Adam K. Leroy[3], Jacqueline Hodge[1], Eve C. Ostriker[2], Juergen Ott[4], Erik Rosolowsky[5], Nicholas Scoville[6], Sylvain Veilleux[2], Axel Weiss[7], Martin Zwaan[8]
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6. Caltech, Pasadena, CA, United States.
7. MPIfR, Bonn, Germany.
8. ESO, Garching, Germany.

Abstract: We present the first results of ALMA cycle 0 observations of NGC 253, the nearest nuclear starburst galaxy. The observations consist of two parts: (1) a 7-point low-resolution mosaic in the CO(1-0) line of the nuclear starburst and its surroundings and (2) a 3-point high-resolution mosaic of the high density tracers HCN and HCO+. The data show clear evidence for molecular gas entrained in the prominent outflow emerging from the central starburst. This is the first time molecular gas is seen in the outflow of NGC 253, a superwind which to date has been studied mainly through through deep H-alpha and X-ray imaging. The high-resolution imaging of the dense gas tracers at the base of the superwind resolve the giant molecular clouds (GMCs) that give rise to the high star formation efficiency of the nuclear starburst. Within the wide bandwidth of the ALMA observations we identify an additional ~25 molecular lines in the central region that trace shocks, dense gas, and optically thin lines such as C17O, H13CO+ and HN13C. The wealth of available data give new key insights into the mechanisms that trigger the central starburst and drive the outflow in NGC 253.

Contributed Oral Abstract #6

Title: aLESS: ALMA observations of submillimeter galaxies from the LABOCA Extended Chandra Deep Field South Survey

Authors: Jacqueline Hodge[1], Alexander Karim[2], Mark Swinbank[2], Andy Biggs[3], Ian Smail[2], Fabian Walter[1], Axel Weiss[4], Rob Ivison[5, 6]
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Abstract: We present an ALMA Cycle 0 survey of ~100 submillimeter galaxies (SMGs) in the Extended Chandra Deep Field South. SMGs are the likely progenitors of massive elliptical galaxies in the local universe, making them key players in models of galaxy formation and evolution. The SMG sample originally derives from the single-dish APEX LABOCA (LESS) survey, the largest, most homogenous, and most sensitive 870um survey to date. Our follow-up Band 7 survey with ALMA's compact array - dubbed aLESS - has produced maps which are ~3 times deeper and have a beam area ~200 times smaller than the original LESS observations. The precise locations afforded by these maps allow us to resolve sources that were previously blended and accurately identify counterparts for these SMGs. Using these precise new locations, we find that previous multiwavelength matching missed ~one-third of SMG counterparts and misidentified one-third of those counterparts it claimed to find. The derived 870um number counts are similar to that found previously, except that the brightest sources have all been resolved into groups of multiple, fainter SMGs. The broad bandwidth of ALMA even results in the serendipitous detection of

[CII] line emission in two previously-unidentified z>4 SMGs. These observations, which took only two minutes per source, demonstrate the power of ALMA already in Early Science.