Terzo Workshop sull'Astronomia millimetrica e submillimetrica in Italia

INAF-Istituto di Radioastronomia
Italian ALMA Regional Center

Centro congressi Area della Ricerca
Bologna, 20-21 Gennaio 2014

Premessa

A distanza di due anni e mezzo dalla precedente edizione il nodo italiano dell'ALMA Regional Centre Europeo organizza il "Terzo Workshop sull'Astronomia millimetrica e submillimetrica in Italia" che si terrà presso l'Istituto di Radioastronomia di Bologna il 20-21 Gennaio 2015.

Il meeting vuole essere un'occasione di incontro per la comunità italiana interessata alla ricerca nel campo (sub)millimetrico. Si discuterà di progetti scientifici già proposti per ALMA o da svilupparsi per il futuro, di progetti proposti per altri strumenti operanti nel millimetrico e di sinergie con strumentazione in altre bande. Verrà dato spazio anche agli sviluppi tecnico-strumentali.

Il meeting si articolerà in sessioni dedicate a ciascuna delle grandi tematiche della ricerca astronomica millimetrica e submillimetrica, dal vicino sistema solare all'universo remoto. Particolare attenzione sarà rivolta ad ALMA ed ai progetti di PI italiani approvati nei primi 3 cicli. Si coglierà altresì l'occasione per presentare i futuri piani di sviluppo del nodo ARC, lasciando momenti di discussione per raccogliere suggerimenti dalla comunità.

Scientific Organizing Committee:
Jan Brand (INAF-IRA, Bologna; Italian ARC)
Viviana Casasola (INAF-IRA, Bologna; Italian ARC)
Riccardo Cesaroni (INAF-OA Arcetri, Firenze)
Davide Elia (INAF-IAPS, Roma)
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Marcella Massardi (INAF-IRA, Bologna; Italian ARC)
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Arturo Mignano (INAF-IRA, Bologna; Italian ARC)
Rosita Paladino (INAF-IRA, Bologna; Italian ARC)

Programma

20 GENNAIO 2015

08.45 - 9.30 Registrazione

ALMA, ARC **Chair: Massardi**

09.30 - 9.35	Massardi	Benvenuto
09.35 - 10.00	i Andreani	Status of the ALMA project
10.00 - 10.20	i Brand	Activities of the Italian ARC node: beyond user support

High-z Universe / Cosmology Chair: Gruppioni

10.20 - 10.45	i Gallerani	Highly excited CO lines in quasars at z>6
10.45 - 11.10	i Gilli	The early coevolution of galaxies with their black holes

11.10 - 11.30 Coffee break

11.30 - 11.50	c Brusa	Evidence for feedback in action from the molecular gas in the z=1.6 outflowing QSO XID2028
11.50 - 12.15	i Marconi	Fast outflows quenching star formation in quasar host galaxies
12.15 - 12.40	i Carniani	ALMA observations of 158mum [CII] line and dust emission in primeval galaxies
12.40 - 13.00	c Vallini	On the [CII]-SFR relation in high-z galaxies

13.00 - 14.00 Pranzo

High-z Universe / Cosmology Chair: Rodighiero

14.00 - 14.20	c Negrello	ALMA follow-up of sub-mm/mm-selected lensed galaxies
14.20 - 14.40	c Bianchi	Observability of High Density Tracing Molecular Lines in Lensed Galaxies with ALMA
14.40 - 15.05	i Giroletti	Unveiling the blazar region with mm-wavelength observations: the ALMA-Fermi connection
15.05 - 15.25	c Massardi	The Planck-ATCA Co-eval Observations (PACO) project
15.25 - 15.50	i Pentericci	Probing the reionisation epoch through millimeter spectroscopy
15.50 - 16.10	c Monaco	Simulating the FIR side of galaxy formation

16.10 - 16.30 Coffee break

Galactic (first session) **Chair: Nisini**

16.30 - 16.55	i Fontani	Fragmentation of massive dense clumps: unveiling the initial conditions of high-mass star formation
16.55 - 17.20	i Elia	Fragmentation in Hi-GAL clumps
17.20 - 17.40	c Massi	Star-forming structures in GMCs: core networks,bubbles, and filaments in the Vela Molecular Ridge

17.40 - 18.00 c Brand The core mass function in star-forming region NGC6357

21 GENNAIO 2015

iALMA **Chair: Fontani**

09.00 - 09.20 i Testi iALMA
09.20 - 09.40 i Villa La componentistica per ricevitori del progetto "iALMA"
09.40 - 10.00 i Palumbo iALMA: Formation of complex molecules after energetic processing of icy grain mantles

Astrochemistry **Chair: Fontani**

10.00 - 10.20 c Dore Millimeter and submm-wave spectroscopy of species of astrophysical importance
10.20 - 10.40 c Marcelino The chemical inventory of pre/proto-stellar cores
10.40 - 11.00 c Maris Laboratory data in support of astronomical detection of molecules

11.00 - 11.20 Coffee break

Galactic (second session) **Chair: Trigilio**

11.20 - 11.45 i Cesaroni Are there disks around O-type protostars?
11.45 - 12.10 i Codella Pristine jet-disk systems around protostars
12.10 - 12.30 c Podio Disk Chemistry with ALMA: first observations of Class 0 disks
12.30 - 12.50 c Guidi ALMA/JVLA observations of the dust properties across the CO snowline in HD163296
12.50 - 13.10 c Santangelo Disentangling the jet emission from low-mass protostellar systems: an ALMA and PdBI view

13.10 - 14.10 Pranzo

Galactic (second session) **Chair: Palla**

14.10 - 14.30 c Leurini IRAS17233-3606: a close view of outflow multiplicity in a massive proto-cluster
14.30 - 14.50 c Moscadelli Unveiling the structure of outflows from high-mass YSOs
14.50 - 15.10 c Rygl Understanding the tracers of star formation
15.10 - 15.30 c Rivilla Radio flares from young stars in Orion

Local Universe **Chair: Prandoni**

15.30 - 15.55 i Agliozzo	Exploring the mass-loss history and the dust content in circumstellar nebulae around three magellanic LBV stars

15.55 - 16.15 Coffee break

16.15 - 16.40 i Hunt	Probing stellar feedback in an extreme low-metallicity starburst
16.40 - 17.00 c Casasola	Feeding and feedback in nearby AGN: From Cycle 0 to Cycle 2
17.00 - 17.20 c Pappalardo	A panchromatic view of the Herschel Virgo Cluster Survey background sources
17.20 - 17.40 c Paladino	Observations of giant molecular clouds in nearby galaxies with ALMA
17.40 - 18.05 i Orienti	Particle acceleration and magnetic field in the hotspot of 3C445

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Talk

High-z Universe / Cosmology

Simona Gallerani
Scuola Normale Superiore, Pisa
Highly excited CO lines in quasars at z>6

I will present the serendipitous detection of the CO(17-16) emission line in a quasar at z=6.4, obtained through the Plateau de Bure Interferometer. This is the most excited CO rotational transition ever detected in such distant galaxies. I will discuss how this detection allows us to strongly constrain the properties of the molecular gas in this distant galaxy. Moreover, I will show that high-J CO (HJCO) lines may provide a sensitive tool to infer the presence of X-ray faint or obscured super massive black hole (SMBH) progenitors in galaxies at z > 6. This hypothesis would be easily tested thanks to the ALMA powerful capabilities. The detection of HJCO lines in other z > 6 quasars would clarify whether the presence of HJCO lines is a peculiar property of galaxies hosting AGN. This kind of experiment outlines exciting possibilities for future discoveries of early SMBH progenitors.

Roberto Gilli
INAF – Osservatorio astronomico di Bologna
The early coevolution of galaxies with their black holes

Hidden AGN in distant submillimeter galaxies (SMGs) feature both efficient nuclear accretion and vigorous star formation. As such, they appear as ideal laboratories to study the concurrent growth of galaxies with their black holes. I will report on ALMA 1.3mm observations of XID403, an SMG at z=4.75 in the Chandra Deep Field South hosting a heavily obscured, Compton-thick QSO. The ALMA data show that the dust heated by star formation is distributed within ~0.9 kpc from the nucleus. The SFR and dust temperature obtained from the Herschel+ALMA far-IR SED, reveal that the starburst is warm and compact, with a surface density of 200 $M_{\odot}/yr/kpc^2$: if most of the host gas mass were confined within the same dust region, then it would be responsible for most of the nuclear absorption measured in the X-rays. It will then be shown that, besides the mass, SFR and gas depletion timescale, objects like XID403 have also the right size to be among the best candidate progenitors of the compact quiescent massive galaxies seen at z~3. Prospects for future high-resolution ALMA observations of similar sources will be finally discussed.

Marcella Brusa
Università di Bologna
Evidence for feedback in action from the molecular gas in the z=1.6 outflowing QSO XID2028

Gas outflows are believed to play a pivotal role in shaping galaxies, as they regulate both star formation and black hole growth. Despite their ubiquitous presence, the origin and the acceleration mechanism of powerful and extended winds is not yet understood. Direct observations of the cold gas component in objects with detected outflows at other wavelengths are needed to assess the impact of the outflow on the host galaxy ISM. We present results obtained with PdBI on an outflowing QSOs at z~1.5, XID2028. The detection of CO(3-2) emission in this source allows us to infer the molecular gas content and compare it to the ISM mass derived from the dust emission. The measured gas fraction and depletion time scale depend on the underlying assumptions on the CO-excitation state and the CO-to-H_2 conversion factor, but the combination of this information and the ISM mass estimated based on the dust mass suggests that its ISM/gas content is significantly lower than expected for the observed M_*, sSFR and redshift, based on the most up-to-date calibrations. The constraints obtained from far

infrared and millimeter data suggest that we are observing QSO feedback in the action of removing the gas from the host.

Alessandro Marconi
Università di Firenze
Fast outflows quenching star formation in quasar host galaxies

AGN feedback is believed to be the physical mechanism linking black hole to galaxy growth as it provides a quick and efficient way to quickly quench star formation and BH growth by sweeping away the gas from the host galaxy. In recent years there has been increasing observational evidence for fast outflows in AGN host galaxies at all wavelengths from X-rays to submm. However we are still missing a convincing, smoking-gun evidence of fast outflows quenching star formation. I will present the results of the study of a small sample of quasars at intermediate redshift where we found evidence for star formation quenching associated to fast ionised outflows in the [O III]]5007 emission line. I will first present the results of integral field observations showing blueshifted conical emission which is anti-correlated with emission in the host galaxy, which is very likely tracing star formation regions. I will show how the physical properties of the outflows compare with observations of molecular outflows and predictions from models of wind acceleration. Finally, I will describe the approved follow-up ALMA observations.

Stefano Carniani
Università di Firenze
ALMA observations of 158mum [CII] line and dust emission in primeval galaxies

We present spatially resolved ALMA observations of [CII] Î»=157.74Î¼m emission from the z = 4.7 BR 1202-0725 system. We investigate the proprieties of the two main prominent sources, a SMG and a QSO, composing the interacting system: the two sources are characterized by a star-formation rate higher than 1000 Msun/yr. However, ALMA observations reveal that these galaxies have an undisturbed rotating disk, which is at a variance with the commonly accepted scenario in which strong star formation activity is induced by major merger. In addition, we report the deepest count SMGs in the 1.1 and 1.3 mm band derived from ALMA Cycle 0 and 1 observations. We resolve ~90% of the Extragalactic Background Light into discrete sources. Finally we show the detection of the [CII] in a faint galaxy at z=7.1, well within the re-ionization epoch. This is the most distant far-IR detection so far, in a system representative of the galaxy population at this epoch.

Livia Vallini
Università di Bologna
On the [CII]-SFR relation in high-z galaxies

After two ALMA observing cycles no detection of the [C II] 158 μm line emission from high-z (z > 6) normal star forming galaxies (SFR~10 $M_{\odot}$/yr) have been reported. This fact poses thorny questions about the validity of the [C II]-SFR relation that have been used to infer the feasibility of such type of observations. To investigate this issue we perform an high-resolution, radiative transfer cosmological simulations that allow us to predict the [C II] 158 μm emission arising from the interstellar medium (ISM) of a z ~ 7 galaxy. The [C II] luminosity (LCII) is achieved by coupling the simulations with: (a) the Vallini et al. (2013) sub-grid ISM model that accounts for the emission from the diffuse neutral gas, and (b) by considering the contribution of Photo-Dissociation Regions as achieved by UCL PDR code. We study the relative contribution of the diffuse neutral gas to the total LCII and its correlation with the following parameters: (i) the star formation rate and, (ii) the profile of the metallicity within the galaxy.

Mattia Negrello
INAF - Osservatorio Astronomico di Padova
ALMA follow-up of sub-mm/mm-selected lensed galaxies

Wide area sub-millimeter and millimeter surveys are delivering large number of strongly lensed galaxies. I will discuss the fundamental contribution of ALMA to the modeling of these lenses and to the study of the background lensed sources.

Eleonora Bianchi
INAF-IRA Università di Bologna
Observability of High Density Tracing Molecular Lines in Lensed Galaxies with ALMA

Molecular emissions can be used to explore the physical conditions and the evolutionary status of near and far away galaxies. Multi-transitions observations can be used as a tool to trace the dense star forming gas within different types of galaxies. New possibilities for the characterization of the molecular properties of high-z galaxies are coming from the Atacama Large Millimeter/Submillimeter Array (ALMA) that promise to explore the evolution of the molecular gas content to an order-of-magnitude-greater level of detail and sensitivity than previous possible. My work aims at investigating the capabilities of the ALMA telescope at observing HCN, HNC, HCO^+ molecular lines in high z lensed galaxies to study the early stages of their formation. It exploits publicly available Cycle 0 ALMA observations of molecular lines in nearby galaxies. The emission is then extrapolated at high z. A gravitational lens model is applied, considering configurations from different positions of the source with respect to the lens. Finally the software CASA is used to simulate ALMA observations and verify detections. The estimated integration times are used to investigate some observing strategies for spectral line surveys of submm flux density limited samples of lensed objects and for a follow-up of extremely magnified sources.

Marcello Giroletti
INAF Istituto di Radioastronomia
Unveiling the blazar region with mm-wavelength observations: the ALMA-Fermi connection

The Large Area Telescope (LAT) onboard Fermi has revolutionized our knowledge of the gamma-ray sky. We found a highly significant (but strongly scattered) correlation between gamma rays and cm-lambda emission in blazars. This correlation has consequences for various topics, including the discrimination between models for the multi-lambda blazar emission and the contribution to the extragalactic diffuse gamma-ray background. We have developed a four-step strategy to address this topic in the mm-lambda regime, where we expect a much tighter correlation: 1-selection of a suitably sized gamma-ray blazar sample, 2-observations of the sample in ALMA Band 6, 3-analysis of simultaneous gamma-ray data, and 4-statistical discussion of the observational results to assess the existence, significance, and implications of the mm-gamma correlation. ALMA has a unique role in this context, as no other observatory can provide data on a statistically significant sample as the one proposed here. It is fundamental that the ALMA observations are carried out during the Fermi mission for simultaneity in the two bands. The project does not require advanced ALMA features, so it is ideal for Early Science.

Marcella Massardi
INAF-IRA, Italian ARC
The Planck-ATCA Co-eval Observations (PACO) project

The Planck-ATCA Co-eval Observations (PACO) project has yielded observations with the Australia Telescope Compact Array of 464, mostly flat- or inverted-spectrum, sources in the frequency range between 4.5 and 40 GHz in the period between July 2009 and August 2010, almost simultaneously with the first two all-sky surveys of the ESA's Planck satellite. The sample is made of 3 complete sub-samples drawn from the Australia Telescope 20 GHz (AT20G) survey catalogue plus a sample of potentially strongly variable sources. The main purpose of the project was to investigate the spectral properties of mm-selected radio sources in the mm bands, combining the ATCA and Planck measurements minimizing the variability effects by observing almost simultaneously with Planck observations. We present the whole catalogue of observations in total intensity, the spectral properties of the sources and discuss their use for calibration purposes for other CMB missions and telescopes and for ALMA.

Laura Pentericci
INAF-OAR
Probing the reionisation epoch through millimeter spectroscopy

The cosmic epoch around z=7 is a crucial phase in the life of the Universe: it marks the end of the dark ages when the intergalactic medium was reionized. Because of the increasing neutral hydrogen fraction as we move to redshift beyond 7, the spectroscopic confirmation of star forming galaxies at this (and earlier) epochs becomes extremely difficult as the Ly-alpha line (the best recognizable signature to determine the redshift) is erased by absorption. ALMA can detect and map the [CII] 158 μm line which is, in general, the brightest line in the spectrum of galaxies accounting for up to 1% of the bolometric luminosity. I will review current observations of high redshift star forming galaxies attempting to detect this line and future prospects on what can be learned about this fascinating epoch of the life of the Universe.

Pierluigi Monaco
Università di Trieste
Simulating the FIR side of galaxy formation

I will show results based on the post-processing of N-body+hydro simulations of galaxy formation. Simulations are based on the GADGET3 code, where star formation and feedback are treated using the novel approach of Murante et al. (2014). Post-processing is based on the GRASIL3D radiative transfer tool, that self-consistently computes the temperature of dust grain and its re-radiation of absorbed UV light. I will present predictions for the FIR and sub-mm luminosity functions, and I will discuss the prospect of measuring outflows powered by SN feedback using molecular lines.

Galactic (First session)

Francesco Fontani
INAF - Osservatorio astrofisico di Arcetri
Fragmentation of massive dense clumps: unveiling the initial conditions of high-mass star formation

High-mass stars are born from the gravitational collapse of massive dense clumps, and the way they form dramatically depends on how the parent clump fragments into cores during collapse: either via competitive accretion in highly fragmented clumps, or through accretion onto single cores if clump fragmentation is suppressed. Simulations of the collapse of massive, turbulent and magnetised clumps show that fragmentation is efficiently inhibited by a strong magnetic support, while if the magnetic field is faint, turbulence dominates and a lot of fragments are expected. To make a substantial progress in this debate and understand which physical mechanism (turbulence or magnetic field?) sets the initial conditions of the high-mass star formation process, ALMA is the best instrument to derive core population (mass, number and distribution of fragments) and kinematics of real pristine massive dense clumps.

Davide Elia
INAF-IAPS
Fragmentation in Hi-GAL clumps

Most high-mass stars seem to exist in a clustered environment, suggesting that their formation from a molecular cloud must involve a process of breaking up into smaller parts. Molecular clumps (linear scales of 0.5 -1.0 pc) are therefore expected to show multiplicity, breaking up in cores (0.05 pc) when observed at high spatial resolution. Understanding the role of fragmentation process in allowing high-mass stars to collect material is not yet complete: the real challenge at this point is to conduct studies of the multiplicity of molecular clumps on a large sample of very cold and massive targets. On one hand, the advent of the Herschel satellite, which combined high sensitivity, dynamic range and spatial resolution in the crucial wavelength range 70-500 μm, and in particular of the Herschel Infrared Galactic Plane Survey (Hi-GAL), allowed the selection of statistically significant samples of such clumps. On the other hand, ALMA, with its high sensitivity and instantaneous u,v-coverage, allows large samples of Herschel-selected molecular clumps to be observed efficiently. The ALMA resolution power, accordingly tuned, gives the unique opportunity to probe smaller linear scales and therefore establish a statistics of how easily IR-clumps break up into cores and what properties these cores have.

Fabrizio Massi
INAF - Osservatorio astrofisico di Arcetri
Star-forming structures in GMCs: core networks,bubbles, and filaments in the Vela Molecular Ridge

In the last few years, mm/sub-mm instrumentation has gained both the resolution and the sensitivity to unveil the smallest gaseous bricks from which stars eventually form, arousing a great deal of interest around filamentary structures in Giant Molecular Clouds. The Vela Molecular Ridge (VMR) is a relatively close-by (700 pc) molecular gas complex composed of several regions in different evolutionary stages. It is therefore suitable for studying how the innermost and densest gas sub-structures evolve towards a final stellar population. We have mapped most of the VMR in the mm and sub-mm dust thermal continuum (with SEST, APEX), which along with BLAST and Herschel far-infrared large scale maps allows us to derive temperature, mass, and density of the cold dust associated with the gas. Selected regions have also been observed in mm emission lines, adding the kinematical information needed to understand the nature of the smallest gas pockets (gravitationally bound or transient entities?). As a result, the population of molecular cores (both pre- and protostellar) in the VMR is now well characterised. I will briefly discuss the main results of these large scale observations (spatial distribution, CMF, etc.) and propose a possible evolutionary path for these structures.

Jan Brand
INAF-IRA, Italian ARC
The core mass function in star-forming region NGC6357

The distribution over mass of stars at birth (the initial mass function, IMF) is one of the most important parameters in star-formation research. What determines the IMF is still not clear, nor is it clear whether the IMF is the same for every star forming region. It does seem, however, that the IMF is set very early on by the mass of the molecular cores out of which the stars form. The core mass function (CMF), and by consequence the IMF, may however depend on the physical and chemical properties of the environment. We present the results of our determination of the CMF at various locations in the Galactic star-forming complex NGC 6357. We used SCUBA2 at the JCMT to observe, at 450 μm and 850 μm, the dust associated with the molecular clouds in a 30′ x 30′ (15pc x 15pc) region containing three HII regions. We assess the radiative and mechanical influence of the stars that excite the HII regions on the molecular gas, by determining the CMF near the HII regions and comparing it with that in more quiescent (less exposed to intense stellar feedback) parts of the complex. Preliminary analysis suggests there is a difference between the CMFs.

iALMA

Leonardo Testi
ESO- INAF - Osservatorio astrofisico di Arcetri
iALMA

iALMA ha come scopo pricipale lo sviluppo di una infrastruttura nazionale per le attività di sviluppo tecnologico, utilizzo scientifico ed esperimenti di laboratorio connessi con l'osservatorio ALMA. Presenterò gli obiettivi a lungo termine del progetto e lo stato di avanzamento attuale.

Fabrizio Villa
Inaf- IASF
La componentistica per ricevitori del progetto "iALMA"

Verranno presentate le attività legate allo sviluppo in Italia della componentistica RF e criogenica per la cartridge in banda 2+3 di ALMA. L'attività è parte integrante del progetto iALMA, premiale INAF.

Maria Elisabetta Palumbo
INAF - Osservatorio Astrofisico di Catania
iALMA: Formation of complex molecules after energetic processing of icy grain mantles

Molecules in the solid phase have been detected towards quiescent molecular clouds and star forming regions as icy mantles on dust grains. Although about 10 molecular species have been firmly identified, it is largely believed that many, also complex, species are present in the solid phase which are not detected due to the detection limits of infrared spectroscopy. It is generally accepted that some of the observed species (e.g. CO) freeze out from the gas phase while others (e.g. water and methanol) are formed on grains after surface reactions. Other species (e.g. CO_2 and OCS), are not expected to freeze out from the gas phase and grain surface models do not account for their observed abundance. It has been suggested that these molecules, along with other more complex species, are formed after energetic processing (i.e. cosmic ion and UV irradiation) of icy grain mantles. All these species are released to the gas-phase after desorption of icy mantles. Here I will present some recent laboratory experiments which show the formation of (complex) molecular species after energetic processing of

simple ices. Furthermore I will describe the new, innovative and more sensitive experimental apparatus we are setting-up in Catania within the project iALMA.

Astrochemistry

Luca Dore
Università di Bologna
Millimeter and submm-wave spectroscopy of species of astrophysical importance

Astronomical observations need support from laboratory for precise rest frequencies. Measurements carried out in Bologna by means of a FM millimeter- submillimeter-wave spectrometer will be presented; the species investigated are molecules produced in a DC discharge and organic molecules. Some results concerning N-15 fractionation in L1544 will be also presented.

Nuria Marcelino
INAF-IRA, Italian ARC
The chemical inventory of pre/proto-stellar cores

Cold dark clouds are the sites of low-mass star formation and future planetary systems. They exhibit a complex gas-phase ion-neutral chemistry leading to the formation of a large variety of molecules. The lack of internal heating sources and violent physical processes, like shocks, make these dense and quiescent cores the best sites to explore and to model interestellar gas-phase chemistry and molecular depletion into the dust grain surfaces. However, they have been found to be less chemically simple than previously thought. Using the IRAM 30m radiotelescope in Spain, we have performed a spectral line survey of the whole 3mm band (82.5-117.5 GHz) toward two prestellar cores, B1-b and TMC-1. Indeed spectral scans are the best tool to provide a complete view of the molecular complexity of dark clouds. Furthermore, unexpected species can provide new information about the physical and chemical evolution of molecular cores toward star formation and complement the usual tracers. In this talk I will present the results of the full 35 GHz scan in B1-b. So far we have detected 325 lines from 109 molecular species and isotopomers. These include unexpected discoveries such as the methoxy radical (CH_3O) and other complex molecular species.

Assimo Maris
Università di Bologna
Laboratory data in support of astronomical detection of molecules

Laboratory characterization of the molecular spectroscopic features is one of the necessary steps in the way of the identification of new species in extra-terrestrial environments. The free jet millimeter wave Stark modulated absorption spectrometer, located in the Chemistry Department of the University of Bologna, allows for the observation of the rotational spectra of systems with molecular weight up to about 200 a.m.u. in the 52-74.4 GHz frequency region.
The experimental work is strongly supported and complemented by the theoretical modelling and calculations with the aim of assigning the observed spectra and to obtain information on the molecular dynamics which involve, for example, conformational rearrangements, large amplitude motions, vibro-rotational coupling and the prediction of vibrational spectra. We will illustrate some experimental details and strategies especially useful in the rotational study of complex organic molecules and we will show some recently achieved results which can be already useful to the astronomical community to analyse the cosmological surveys.

Galactic (Second session)

Riccardo Cesaroni
INAF - Osservatorio Astrofisico di Arcetri
Are there disks around O-type protostars?

La teoria prevede che le stelle di alta massa (O ed early-B) possano formarsi a dispetto della forte pressione di radiazione, se l'accrescimento viene mediato da un disco circumstellare. L'osservazione di tale disco risulta però ardua a causa della distanza (diversi kpc) e del fatto che queste stelle si trovano in ricchi ammassi dentro a nuclei molecolari densi e opachi. Le osservazioni interferometriche nel (sub)mm rappresentano un eccellente strumento per superare questi ostacoli. In particolare ALMA possiede la risoluzione angolare (e sensibilità) sufficiente a risolvere i dischi previsti attorno alle stelle di alta massa. Su questa base abbiamo utilizzato ALMA nel Ciclo 0 per rivelare due dischi circumstellari attorno a stelle giovani con luminosità di $\sim 10^4$ $L_\odot$, dimostrando così la stretta relazione fra dischi di accrescimento e stelle di tipo B. Con la nuova proposta approvata per il Ciclo 2, ci riproponiamo di rivelare per la prima volta un disco attorno ad una stella giovane di tipo O. A questo scopo abbiamo selezionato un campione di 6 sorgenti con luminosità di circa 10^5 Lo associate a nuclei densi e caldi. Nella presentazione verranno illustrati i risultati ottenuti e il metodo utilizzato per la ricerca di dischi attorno a (proto)stelle O.

Claudio Codella
INAF - Osservatorio Astrofisico di Arcetri
Pristine jet-disk systems around protostars

The launching of jets from protostars remains one of the most enigmatic phenomena in astrophysics. Jets are launched via a magneto-hydrodynamical (MHD) process removing excess angular momentum, and allowing accretion onto the protostar. MHD simulations of protostellar collapse argue that magnetic braking by twisted B-fields is so efficient that Keplerian disks would be initially suppressed beyond 10 AU (the “magnetic braking catastrophe”). However, much larger Keplerian disks (100-150 AU) have been already reported in two protostars (L1527, VLA1623), raising the acute question of their formation. We present ALMA observations of HH212, a protostar driving a strikingly bipolar H_2/SiO collimated jet. We show how ALMA-Band 7 data can trace in unprecedented detail, and within a single spectral set-up, all the crucial ingredients involved in the star-disk formation recipe, namely: (i) the dusty protostar; (ii) the axial jet launched from it; (iii) the biconical outflow cavities; (iv) the parent infalling envelope; (v) the forming Keplerian disk. We reveal different kinematics among chemical tracers, and more asymmetric structures than predicted by simple models, with significant contribution from the rotating swept-up cavity. In particular, we will focus on the high-excitation molecular emission indicating a combination of infall and rotation, with a keplerian disk nested inside.

Linda Podio
INAF - Osservatorio Astrofisico di Arcetri
Disk Chemistry with ALMA: first observations of Class 0 disks

Protoplanetary disks are the birthplace of planets. Knowledge of their molecular content is crucial to understanding how planets, asteroids, and comets inherit their chemical composition. Only a few molecules are routinely detected in disks (e.g., CO, CN, HCO^+), while most of them remain hidden on the icy grains in the mid-plane and outer disk regions. With its unprecedented resolution and sensitivity ALMA will revolutionise our comprehension of the disk chemistry not only in evolved disks but also in disks around young protostars. ALMA observations of the low-mass Class 0 protostar HH 212 allowed the detection of SO high-excitation emission from the inner rotating disk mapped by Codella et al. 2014. This detection is particularly interesting as the chemistry of sulfur-bearing molecules in disks is poorly understood and SO has proved to be difficult to detect even in evolved disks. We estimate an SO abundance of 10^{-8}-10^{-7}, in agreement with the predictions of self-

gravitating disk models. This indicates that the chemistry of young disks may be dominated by a strong enhancement of the molecules abundance in the shocks induced by gravitational instabilities. These studies are crucial to shed light on the chemistry of disks at the early stages of their formation.

Greta Guidi
INAF Osservatorio astrofisico di Arcetri, Universita' di Firenze
ALMA/JVLA observations of the dust properties across the CO snowline in HD163296

Recent interferometric observations with ALMA allowed to resolve the CO snowline in the midplane of the disk around HD163296. From the comparison between images at different wavelengths (ALMA Band 6 and 7, JVLA Ka Band) it was possible to infer the size of the grains as a function of the radius, through the measurement of the opacity spectral index. This analysis suggests the presence of larger grains (millimeter to centimeter sized) in the inner regions inside the CO snowline, and smaller grains (less than millimeter sized) in the outer regions. The results are consistent with the hypothesis that grain have been processed in this disk and have experienced inward migration.

Gina Santangelo
INAF - Osservatorio Astronomico di Roma
Disentangling the jet emission from low-mass protostellar systems: an ALMA and PdBI view

The key to constrain protostar formation models lies in high-resolution studies of the youngest protostars. Class 0 protostars represent the earliest stage of low-mass star formation. A quite limited number of Class 0 sources has been observed so far at sub-arcsecond resolution in the (sub)mm, needed to probe their innermost regions in order to disentangle emission from the different processes: the launch of the jet, the chemistry of the hot corino, the disk formation. As a consequence, their physics is still poorly understood and several fundamental questions remain open, such as the existence of multiple systems and their evolution, the launching mechanism of protostellar jets and their timescales with respect to the hot-corino phase. I will present ALMA and PdBI observations of typical tracers of shocked gas (CO, SiO, SO) in two low-mass protostellar systems: VLA1623 and NGC1333-IRAS4A. I will also show comparisons with Spitzer and Herschel observations of H_2, [O I], H_2O, and high-J CO emissions. The data allow us to disentangle the jet emission from the single components of the protostellar systems and to analyse the properties of the jet and the driving sources. I will discuss the results and try to give answers to the above questions.

Silvia Leurini
MPIfR
IRAS17233-3606: a close view of outflow multiplicity in a massive proto-cluster

In this talk, I will present high resolution observations of the massive star-forming region IRAS 17233-3606 with the SMA array complemented by H_2 at 2.12 micron. Due to its close distance (D~700 pc), IRAS 17233-3606 allows us to get an exceptionally detailed view of a massive proto-cluster and it is an ideal laboratory to investigate the kinematics of the gas in the proximity of the YSOs. Thanks to detection of typical outflow and jet tracers (CO, SiO and H_2) at comparable resolutions, we resolve 3 outflows with high collimations and emission at extremely high velocity. This allows us to interpret larger scale emission of key molecules and determine, for example, a high abundance of water at high velocities. The detailed knowledge of the multplicity of outflows in the region allows us to study the velocity field of other species and verify that several of them are contaminated by outflow motion. I will conclude the talk by presenting a close comparison of the outflows in IRAS 17233-3606 with low-mass outflows studied in deep details with ALMA and PdBI. In particular one of the massive outflow in IRAS 17233-3606 shows very close similarities with low-mass outflows in terms of kinematical properties.

Luca Moscadelli
INAF - Osservatorio Astrofisico di Arcetri
Unveiling the structure of outflows from high-mass YSOs

Notwithstanding many recent advancements in the observational technique and computational modelling, our knowledge of the process of formation of high-mass (> 7 $M_\odot$) stars is still poor. Mass accretion and ejection mediated by a disk/jet system as observed in low-mass (~ 1 $M_\odot$) Young Stellar Objects (YSO), might not be the main route of formation of more massive stars. Considering the tight connection between mass accretion and ejection predicted by all star formation models, a detailed study of the ejection mechanism in high-mass YSOs can be the key to understanding their structure. A linear resolution on the order of 100~AU is mandatory for resolving the individual YSO's flow contribution from the complex outflow pattern produced by nearby (high- and low-mass) forming stars. We investigate the structure of the molecular content of the flow at milliarcsec angular resolution with VLBI of the 22~GHz water masers, and characterize the emission of the ionized flow at different frequencies (6, 13, and 22~GHz), by exploiting the sensitivity of the upgraded JVLA. Our target sample consists of 40 high-mass YSOs, selected from the list of BeSSeL targets. This talk reports on the first results obtained for a subset of eleven sources recently analyzed.

Kazi Rygl
ESA-Estec
Understanding the tracers of star formation

Infrared to cm continuum and spectral line data are crucial to investigate the evolution of young stellar objects (YSOs). We discuss the star formation around the W48 HII region where we detected an age gradient in various tracers using a multi-wavelength multi-observatory dataset which suggested that the formation of this star-forming region might be related to the Aquila supershell. In general, age estimates are highly uncertain because the evolutionary models of high-mass star formation contain many unknowns, such as when the star actually ignites, and which tracers mark this transition. One of such tracers is the 6.7 GHz methanol maser transition pumped by infrared emission. Recently, new JVLA data revealed that many YSOs with methanol masers that previously had no known continuum detections, in fact show free-free emission, a sign of the ionising emission of a newly formed star. To test if the methanol masers are always excited during the first stages of stellar ignition we started a search for free-free emission towards young YSOs with methanol masers.

Victor Rivilla
INAF - Osservatorio Astrofisico di Arcetri
Radio flares from young stars in Orion

While the X-ray flaring rate of young stars is well understood, only a few radio flares have been detected. Are they rare events or were the observations carried out so far not sensitive enough? We used the Very Large Array interferometer to carry out a multi-epoch radio continuum monitoring of the Orion Nebula Cluster to answer this question. Most of the radio sources we detected show clear radio variability, including hours-days timescales. We have estimated a rough radio flaring rate of 0.14 flares/day in the densest stellar cluster of the region, suggesting that radio flares are relatively common events. Combining the radio sample of sources with the X-ray catalog from Chandra, we found that the radio detections have been strongly limited to the brighter X-ray stars. The improved sensitivity of ALMA will dramatically increase the number of stars in young clusters detected at (sub)millimeter wavelengths. A more accurate determination of the flaring rate would help to understand how this variability can affect the upcoming sensitive interferometric observations in young stellar clusters, since the classical synthesis imaging techniques assume a constant sky.

Claudia Agliozzo
Universidad Andres Bello
Exploring the mass-loss history and the dust content in circumstellar nebulae around three magellanic LBV stars

A Luminous Blue Variable (LBV) represents a crucial phase of the post-Main Sequence evolution of a massive star, during which it loses most of its mass through stellar winds and/or eruptions and forms dusty circum-stellar nebulae. The main mechanism responsible for the mass-loss in these stars has not been established, but the possibility that it is independent of metallicity is of paramount importance to LBVs occurred in the metal-poor Universe. Multiwavelength observations of galactic LBV nebulae (LBVNe) revealed the presence of big amounts of dust, making these stars promising channels for dust production in the early Universe. Unfortunately, a paucity of data exists in lower-metallicity environments such as the Magellanic Clouds, mostly because the IR instruments have not been suitable for high-resolution and high-sensitivity observations. Therefore, the presence of dust in extra-galactic LBVNe is still an open issue. However, our multi-wavelength study evidences the presence of possible dust in three magellanic LBVNe. We discuss our strategy for observing these objects with ALMA during Cycle 2, aimed at confirming the presence of dust and at deriving important physical information from the sub-mm dataset.

Local Universe

Leslie Hunt
INAF - Osservatorio Astrofisico di Arcetri
Probing stellar feedback in an extreme low-metallicity starburst

Feedback from accreting black holes and from massive stars and supernovae has become a cornerstone for understanding galaxy evolution. Recent theoretical work has shown that dust is an important aspect of stellar feedback because of the interaction of photons with dust grains. However, in the early universe, when galaxies were very metal poor, there are no observational constraints for stellar feedback, even though dust is known to play a role in primordial star formation. We will obtain in Cycle 2 high-resolution (0.2 arcsec) Band 9 (450 μm) observations of an extremely low-metallicity starburst, SBS0335-052, at 1/30 solar oxygen abundance. These observations, a follow-up of our successful Cycle 0 proposal, will enable us to compare dust morphology at a resolution of 55 pc with the distribution of the young massive Super Star Clusters. We will determine the contribution of free-free to the observed emission using high-frequency radio observations at the same resolution. Our proposed observations will provide for the first time constraints of feedback models in an extremely metal-poor interstellar medium, and better establish the metallicity dependence of dust content and column density.

Viviana Casasola
INAF-IRA, Italian ARC
Feeding and feedback in nearby AGN: From Cycle 0 to Cycle 2

I present how ALMA is transforming our knowledge on the central engine of active galactic nuclei (AGN). From Cycle 0 to Cycle 2, ALMA has indeed probed AGN feeding and feedback phenomena through the morphology and dynamics of the gas inside the central kpc of Seyfert nuclei (e.g., NGC 1433, NGC 1566, NGC 1068, Mrk 590) at the unprecedented spatial resolution of ~25 pc. The scenarios emerging from the same class of objects are heterogeneous: gas fueling, AGN-driven outflow, very dense molecular gas, nuclear dust emission corresponding to the molecular torus, and so on. Some of these results come as a surprise in addition to be an essential step toward even higher resolution observations offered soon by ALMA Cycle 3 and full array.

Ciro Pappalardo
IA-CAAUL-OAL
A panchromatic view of the Herschel Virgo Cluster Survey background sources

The evolution of galaxies is set by a complex mechanism of recycling between the stellar and the gaseous components, a process that evolves with time and depends strictly on the reservoir of gas and dust available for the star formation. In order to investigate these processes in nearby Universe, we built a sample of ~2000 galaxies selected at 250 micron at z<0.4 for which we have robust estimation of flux densities between 60 and 500 micron. We joined to these data photometric estimation obtained with Galex, SDSS, 2MASS, and WISE to have a multi-wavelengths view of each object. We then apply an energy-balanced technique of SED fitting and we estimate different physical parameters, such as star formation, stellar mass, and total IR luminosities. Galaxies at z~0.1 have typical Dust Mass of 10^8 solar masses, and span a large range of star formation rate, between 0.001 to 50 solar masses per year. We investigate also the impact of removing different data set from the SED fitting procedure. We found that Mid Infra red wavelengths have a strong impact in determining the balance between the gas component heated by the interstellar radiation field and the gas component heated in young clouds.

Rosita Paladino
Università di Bologna, INAF-IRA, Italian ARC
Observations of giant molecular clouds in nearby galaxies with ALMA.

ALMA's unprecedented angular resolutions will allow detailed studies of physical conditions in giant molecular clouds in galaxies up to 10 Mpc. I will show simulations of ALMA observations of a galactic giant molecular cloud, showing how it would appear at different distances, and how far it will still be possible to resolve structures and study their dynamical properties.

Monica Orienti
INAF-IRA
Particle acceleration and magnetic field in the hotspot of 3C445

Radio hotspots are bright and compact regions located at the edge of powerful radio galaxies. In the standard scenario they mark the place where the supersonic jet interacts with the ambient medium and produces shocks. The discovery of synchrotron optical emission extending on kpc scale challenged this scenario, suggesting that additional efficient acceleration mechanisms must be at work. However, the physical process at the basis of the diffuse emission is still controversial. I will briefly discuss the peculiar case of the hotspot 3C 445 and the role of the ALMA observations in discriminating the acceleration mechanism at work.

Poster

Enrica Bellocchi
CAB-CSIC/INTA
Molecular line analysis of local star-forming galaxies using Herschel/HIFI and APEX data

We present the preliminary results obtained from using the far-IR Herschel/HIFI observations (480 to 1910 GHz) combining them with APEX data at sub-mm wavelengths (200-1500 GHz) of the local star-forming galaxies NGC4945, NGC253 and Arp220.
We carried out a Local Equilibrium Analysis (LTE) using the MADCUBA_IJ (Madrid Data Cube Analysis in ImageJ) software applied to the integrated spectra, which allows to provide some main physical parameters of the galaxy (e.g., column density N_{mol}, excitation temperature T_{ex} and local standard of rest velocity v_{LSR}). We detected in emission CO, ^{13}CO, CI and CH along with some dense gas tracers such as HNC, HCN, HCO^+, CS. A LVG analysis (i.e., non-LTE RADEX) has been performed as well, allowing us to derive the number density of H_2 molecules in the cloud. These results are in agreement with those derived when applying LTE analysis in the optically thin regime.
The high sensitivity and angular resolving power of ALMA will allow to map in detail the molecular gas distribution, giving information on both pc and kpc scales needed to explore the relationship between star formation, gas density and gas kinematics, in comparison with other tracers, like the atomic and ionized gas.

Elisabetta Liuzzo
INAF-IRA, Italian ARC
The jet of the BL Lac object PKS 0521-365 in the mm-band: ALMA observations

BL Lac objects are low-power active nuclei exhibiting a variety of peculiar properties caused by the presence of a relativistic jet and orientation effects. Since the jet is closely aligned with the line of sight, it is very difficult to observe unless the angular resolution is high. At millimeter wavelengths in particular, until the advent of ALMA, information on the jet emission was lacking from the previous facilities. Here we report our results on the millimeter emission of PKS 0521-365 which is a well-studied and remarkably nearby BL Lac of the southern sky, and also one of the few extragalactic sources showing a well resolved jet at all bands, from radio to X-ray. Using data in the ALMA archive, we analyzed its B3-B6-B7-B9 continuum emission and CO emission line. We made SED and morphological analysis of each source component (jet and knots, nucleus, lobe). Finally, we discussed the results obtained for this source in the more general context of the ALMA bands emission properties compared with the other class of AGN.

Sonia Melandri
Università di Bologna
Millimeter wave spectroscopy of flexible molecules relevant to astrochemistry

The investigation of phenomena related to the chemistry of the Cosmos is strongly based on the identification and quantification of molecules by spectroscopic methods (in particular by rotational spectroscopy) and laboratory work is essential to provide the community with the spectral features needed to analyze the cosmological surveys.
Many of the molecules which are searched for in space, are complex organic molecules which show a high degree of molecular flexibility. The high number of low energy conformations and the presence of large amplitude motions on shallow potential energy surfaces are peculiar to this kind of systems giving rise to very complex rotational spectra, which represent a challenge for spectroscopic and computational methods.
Spectroscopic strategies for the rotational study of flexible organic molecules include the use of the cold and isolated conditions of a free jet expansion and laser ablation sources for the non volatile systems while the

computational methods must deal with complex conformational surfaces and large amplitude motions which can cause tunneling splittings of the rotational transitions.
We will give examples of spectroscopy of molecules of astrophysical interest studied by the Free Jet Spectroscopy Group in Bologna with instruments going from 6 to 78 GHz.

Vincenzo Galluzzi
INAF-IRA, Italian ARC, Università di Bologna
Polarimetric multi-frequency observations of a complete sample of radiosources

The polarization properties of extragalactic radio sources at high frequencies (> 20 GHz) are still poorly constrained. Extending such characterization to high frequencies would provide invaluable information about the physics of the emission processes, mostly dominated by self-absorbed, knot-like synchrotron signal from relativistic jets closer and closer to a Doopler-boosted active nucleus. It has been argued that the ordering of magnetic fields should increase in the inner regions, giving a higher polarization degree at higher frequency (cfr. Tucci et al., 2004). However, Massardi et al. (2013) have found no statistically significant relationship between the polarization fraction and the total intensity flux density, and no clear indications of trends of fractional polarization with frequency up to 20 GHz. In this project, thanks to new ATCA observations (allocated in September 2014) on a complete sample of 53 sources of the faint PACO sample, we aim to reconstruct the source polarization spectral behaviour across a a wide frequency range, and to deeper flux density levels than available so far. Hence, we are going to submit a proposal in order to extend polarimetric observations up to 100 GHz by using ALMA, at least on the 53 sources of the faint PACO sample.