PROGRAM of the RIA Workshop

"IMPACT OF ALMA ON THE SPANISH EXTRAGALACTIC ASTRONOMY"

11th February

8:45 – 9:15 Registration

Session 1: INTRODUCTION TO THE ALMA PROJECT

Chair: J. Alves

9:15 Opening of the workshop
J. Martín-Pintado (Spanish working group for ALMA, RIA)
9:30 The ALMA Project: status and progress towards science operations
L. Testi (ESO, Germany)
10:00 IRAM node: Support for Spanish astronomers
P. Salome (IRAM, France)
10:20 MADCUBA: Tools for Advanced Data Cube Analysis
J. Martín Pintado (CAB-CSIC, Spain)
10:50 ARTIST: Adaptable Radiative Innovations for Submillimeter Telescopes
J. M. Girart (ICE (CSIC)-IEEC, Spain)

11:10 - 11:40 Coffee Break

Chair: J. Masegosa

11:40 ALMA 3D: Analysis, visualization and VO tools for datacubes.
L. Verdes-Montenegro (IAA-CSIC, Spain)
12:10 A general view of extragalactic projects with ALMA
T. Wiklind (STSCI, USA)

Session 2: NEARBY GALAXIES: DETAILED STUDIES

Chair: J. Masegosa

12:40 Star formation and THINGS: a question of balance between H2 and HI
E. Brinks (Univ. of Hertfordshire, UK)
13:10 Star formation laws in nearby galaxies Like M51 and M33
C. Kramer (IRAM, Spain)
13:30 AGN feeding: a molecular line perspective
S. Garcia-Burillo (OAN, Spain)

14:00 - 16:00 Lunch

Chair: S. Leon

16:00 Spectral line surveys in the ALMA era
S. Martin (CfA, USA)
16:20 Resolving the drivers of molecular gas chemistry in starburst and AGN galaxies
A. Usero (OAN, Spain)
16:40 Chemical modelling of the interstellar medium (ISM) in external galaxies: the case of M82
A. Fuente (OAN, Spain)
17:00 Using High excitation molecular lines to trace the gas in AGNs
J. Cernicharo (CAB-CSIC, Spain)
17:20 The molecular gas content in Blue Compact Galaxies
R. Amorín (IAA-CSIC, Spain)
17:40 The role of ALMA in extragalactic star-formation studies
J. A. Fernández-Ontiveros (IAC, Spain)

18:00 – 18:45 Discussion session: A. Díaz & E. Brinks
Wine & cheese degustation

12th February

Session 3: ENVIRONMENT

Chair: C. Muñoz-Tuñón

9:30 Strong interactions and mergers: The role of molecular gas in the evolution of ULIRGs, PRGs and QSOs
D. Sanders (Univ. Hawaii, USA)
10:00 Studying galaxy evolution in isolated galaxies with ALMA
D. Espada (IAA-CSIC-Spain/CfA-USA)
10.20 Hot spots in radiogalaxies
M. Orienti (IAC, Spain)

Session 4: HIGH-Z SYSTEMS AND COSMOLOGY

Chair: C. Muñoz-Tuñón

10:40 Evolution of galaxies and AGN with their environmental connections at high z
N. Scoville (CalTech, USA)

11:10 – 11:40 Coffee break

Chair: V. Martinez

11:40 An IR perspective on the assembly of galaxies at z>1 and the role of AGN: from Spitzer to ALMA
P. Pérez-González (Univ. Complutense Madrid, Spain)
12:00 Studying stellar mass build up in high redshift galaxies using ALMA
M. Yun (UMass, USA)
12:30 FIR continuum+line properties of nearby galaxies as local benchmark for future ALMA studies at high redshift
A. Gil de Paz (Univ. Complutense Madrid, Spain)
12:50 Cosmology with ALMA using the Sunyaev-Zeldovich effect
J. A. Rubiño (IAC, Spain))

13:10 – 15:30 Lunch

Session 5 PREPARING FOR ALMA: SYNERGIES

Chair: U. Lisenfeld

15:30 The ALHAMBRA and the Javalambre/PAU surveys
J. Benitez (IAA-CSIC, Spain)
16:00 OSIRIS Surveys and ALMA, plus other extragalactic synergies
J. Cepa (IAC, Spain)
16:30 Sinergies between ALMA and GOYA
M. Balcells (IAC, Spain)
17:00 Extragalactic surveys with Herschel and Spitzer and follow-up projects with ALMA
N. Castro (IAC, Spain)

17:30 – 18:30 Discussion: **I. Márquez & D. Sanders**
Degustation of teas and Arabic pastries

20:30 Conference dinner

13th February

Session 5 PREPARING FOR ALMA: SYNERGIES (cont)

Chair: E. Battaner

9:30 Single dish FIR to millimeter-wavelength facilities in the era of ALMA
D. Hughes (INAOE. Mexico)
10:00 Millimeter and submillimeter interferometry in preparation for ALMA
P.T.P. Ho (CfA-USA, ASIAA-Taiwan)
10:30 Millimeter-VLBI with Large Millimeter Arrays
A. Alberdi (IAA-CSIC, Spain)
10:50 Synergies between ALMA and SKA
J. C. Guirado (Univ. Valencia, SPAIN)

11:10 – 11:40 Coffee break

Chair: J. M. Vílchez

11:40 The GTC in the world of ALMA
J. M. Rodriguez Espinosa (IAC, Spain)
12:10 SAFARI, an European FIR instrument for SPICA in the ALMA context.
J. Goicoechea (CAB-CSIC, Spain)
12.30 Synergies between low and high energies: Obscured AGN growth and galaxy formation
F. Carrera (IFCA-CSIC, Spain)
12.50 First-light follow-up of AzTEC sources with ALMA
I. Aretxaga (INAOE, México)

13:10 – 13:50 Final discusión: S. Garcia-Burillo & N. Scoville
Conclusions: L. Verdes-Montenegro & J. Masegosa

POSTERS

Structure and properties of dense molecular gas in the nucleus of starburst galaxies.
R. Aladro(IRAM, Spain)
Toward gain calibration in ALMA: fast-switching tests in the SMA
V.Martínez-Badenes (IAA-CSIC, Spain)
Molecular gas disk in the center of nearby elliptical radio galaxies?
B. Ocaña Flaquer (IRAM, Spain)
Herschel M33 extended survey (HERMES)
G. Quintana-Lacaci (IRAM, Spain)
Disk-Halo interface: Studying the "foot point" of two Galactic Molecular Loops as a template for external galaxies
D. Riquelme (IRAM, Spain)
Hα imaging of JCMT nearby galaxies legacy survey targets
J. R. Sánchez Gallego (IAC, Spain)
Integrating the ALMA Science Archive in the VO.
J. d D. Santander (IAA-CSIC, Spain)
Panchromatic analysis of the star formation processes in M33.
S. Verley (CSIC, Spain-UNAM, Mexico)

ABSTRACTS OF ORAL CONTRIBUTIONS

Millimeter-VLBI with large millimeter arrays

Alberdi, A. (IAA-CSIC, Spain)

We will present the possibilities and sensitivity improvements which could be obtained if a phased-array with a large number of antennas working at mm- and submm-wavelengths (like ALMA) is used as an element of the VLBI array at millimeter wavelengths. The addition of such an instrument will push the detection limit of such an array by, at least, an order of magnitude.

The molecular gas content in Blue Compact Galaxies

Amorín, R. (IAA-CSIC, Spain), Muñoz-Tuñón, C., Aguerri J.A.L &. Planesas. P

The knowledge of the molecular gas content, spatial distribution and physical conditions are essential for understanding the star formation processes and their impact on the ISM in star-forming galaxies. However, these galaxies are difficult to detect in molecular lines.
In this talk, we present a deep survey for 12^CO J=1-0 and J=2-1 emission line toward the galaxy center of a sample of 10 Blue Compact Galaxies using the IRAM 30m telescope. Results on the molecular content and their relation with multiwavelength global properties of the BCG host galaxies will be discussed.
This research aims to be the first step in order to develop scientific cases for potential ALMA projects.

First-light follow-up of AzTEC sources with ALMA

Aretxaga I. (INAOE, México) and the AzTEC collab (UMass, USA; Japan; UK; Korea).

AzTEC is an efficient bolometer camera that, coupled with the 15m JCMT and the 10m ASTE telescopes, has mapped at 1.1mm more than 3 sq. deg of the extragalactic sky to depths between 0.7 and 1.1 mJy, prior to its installation on the 50m LMT. These extragalactic surveys have allowed our scientific team to derive catalogs of ~1000 robustly-detected powerful starbursts and AGN at high-redshifts. The main goal of these surveys is to derive an accurate estimation of the star formation history that takes place in obscured starbursts, and determine if the destinies of these galaxies are the massive spheroids that we detect in the nearby universe. Given the size of the sample we are able to measure changes in the evolution between field galaxies and massive proto-clusters. Follow-up imaging with sensitive mm-wavelength interferometers will allow us to refine the coarser mm-positions of our catalogs, decide whether the mm-source is a single galaxy or a multiple system in coalescence, identify potential optical/IR counterparts to measure photometric and spectroscopic redshifts, determine their stellar population/AGN content and their current evolutionary stage.

Sinergies between ALMA and GOYA

Balcells, M. (IAC, Spain)

I will discuss how millimeter observations of CO transitions will complement GOYA NIR spectroscopy of z = 1 - 2.5 galaxies with GTC/EMIR. Thanks to the negative K-correction affecting millimeter and submillimeter fluxes, ALMA will also contribute to GOYA's efforts at characterizing the population of very distant galaxies at z > 7.

The ALHAMBRA and the Javalambre/PAU Surveys

Benítez, J. (IMAFF-CSIC, Spain)

The Advanced Large Homogeneous Area Medium-Band Redshift Astronomical (ALHAMBRA) survey is employing 20 contiguous, equal-width, medium-band filters covering from 3500 Å to 9700 Å, plus the standard JHKs near-infrared (NIR) bands, to observe a total area of 4 deg2 on the sky. The optical photometric system has been designed to maximize the number of objects with accurate classification by spectral energy distribution type and redshift, and to be sensitive to relatively faint emission features in the spectrum. We present some preliminary results for those fields which have already been observed with the full filter set. We also introduce the future Javalambre/PAU Survey, which will image the full northern sky with 40 medium band filters from a dedicated 2.5m, 6sq.deg field telescope at the new Javalambre Observatory in Teruel, and whose scientific goals include high precision measurements of the scale length of Baryonic Acoustic Oscillations, a powerful tool to characterize dark energy.

Star formation and THINGS: a question of balance between H2 and HI

Brinks, E. (Univ. of Hertfordshire, UK)

We know that stars form in cold, molecular gas, in Giant Molecular Clouds, which in turn need to assemble from the cool atomic gas. Knowing the total gas surface density and the relative proportion between H2 and HI, one should be able to apply the Schmidth-Kennicutt law and predict the star formation rate density. I will present results from the THINGS (The HI Nearby Galaxy Survey) consortium who have investigated this in a sample of nearby galaxies. Building on those results, I will indicate how ALMA not only will be able to address the questions raised by the THINGS study but push this to higher redshifts.

Obscured AGN growth and galaxy formation: synergies between low and high energies

Carrera, F. (IFCA-CSIC, Spain), Barcons, X.

The relationship between star formation and super-massive black hole growth is central to our understanding of galaxy formation and evolution. Unfortunately, both processes tend to happen in heavily obscured environments, which provide their "fuel". Because of this obscuration, the former is best detected through long wavelength emission from heated dust, while the unequivocal signature from the latter is hard X-ray emission from the accreting matter. This complementarity of astrophysical processes and observational signatures provides the prospect for strong synergies between ALMA and existing and forthcoming X-ray observatories, which together could help to disentangle the contribution from both phenomena to the bolometric luminosities of Active Galactic

Nuclei and Luminous IR Galaxies, and their interplay in the building of present day galaxies

Extragalactic surveys with Herschel and Spitzer and follow-up projects with ALMA

Castro-Rodríguez, N. (IAC, Spain), Pérez-Fournón, I, Cava, A., HerMES, ATLAS, SERVS

A central challenge in astrophysics today is to understand the complex processes of galaxy formation: the development of galactic structure, the conversion of gas into stars, and the growth of supermassive black holes.
The far-infrared / submillimetre waveband is of particular importance for studying these processes because roughly half of the cosmic energy density produced by galaxies arises from optical/UV starlight that has been absorbed by dust and reradiated at these wavelengths.
In 2009 the Herschel Space Observatory will start the crucial observations of extragalactic fields in the far-infrared which are needed to complete the picture of galaxy formation and evolution at high-redshift. The Herschel extragalactic surveys will provide large samples of galaxies with well known infrared properties for detailed analysis with ALMA.
In this talk we will review the Herschel cosmological surveys (HerMES, PEP, Herschel-ATLAS, and GOODS-Herschel) and other related large-area and deep surveys with the Spitzer Space Telescope (such as SWIRE and SERVS) and discuss the role that these observations will have to select samples of galaxies for observations with ALMA.

OSIRIS Surveys and ALMA, plus other extragalactic synergies

Cepa, J. (IAC, Spain)

OSIRIS will begin routinely operation at the GTC in March 2009. The availability of a significant amount of observing time in a 10m telescope, will allow the Spanish astronomical community to carry out several extragalactic surveys based on different OSIRIS observing modes, using different observing time frameworks. These surveys will provide large and unique databases, with fruitful relations with surveys at other wavelengths, and with foreseen synergies with future mm observations using ALMA. Viceversa, high scope ALMA studies can exploit these optical-NIR-FIR databases. A brief summary of some of the different surveys proposed will be provided, and the expected benefits of this multiple-wavelength complementarity will be discussed.

Using High excitation molecular lines to trace the gas in AGNs

Cernicharo, J. (CAB-CSIC, Spain)

Although many molecular lines have been detected towards nearby galaxies only a few molecular species have been observed towards high redshift objects. ALMA will provide the possibility to observe high excitation maser lines of water vapor in the submillimeter domain. I will discuss what information can be obtained from these lines and how they can be used to trace the gas around the center of AGNs. I will also discuss the pumping mechanism of species like HCN in these objects.

Studying galaxy evolution in isolated galaxies with ALMA

Espada, D. (IAA-CSIC, Spain/Havard Smithsonian CfA-Harvard, USA) & AMIGA team

In this talk I will show why studying the most isolated galaxies is essential to gain a better understanding of the role of the environment on evolution of galaxies. Due to lack of sensitive instruments in the mm/submm wavelengths, most of the studies on the molecular gas in galaxies are biased towards the most infrared luminous galaxies, which are usually interacting. Therefore, little is known about the molecular gas properties in the most isolated galaxies. The AMIGA (Analysis of the interstellar Medium of Isolated GAlaxies) project is generating the missing reference sample. The aim is to analyze a multiwavelength database (optical, IR, HI, CO, and radiocontinuum) for a large (N~1000) and complete sample of isolated galaxies. We aim to image with high-resolution part of this sample using ALMA, program that is not feasible with current instrumentation, in order to study the morphology and kinematics, excitation conditions and chemistry of the molecular phase in isolated galaxies. We will highlight our current efforts using the Submillimeter Array (SMA) to study the molecular gas properties in the brightest galaxies of the AMIGA sample.

The role of ALMA in extragalactic star-formation studies

J. A. Fernández-Ontiveros (IAC, Spain), Prieto, A., Acosta-Pulido, J., Orienti, M.

Young massive clusters are the birthplaces of nearly all massive stars and, like them, remain deeply obscured in the earliest stages of their evolution. These systems have been studied in the central region of two nearby starburst galaxies, NGC 253 and NGC 7582, using VLT/NACO adaptive optics in the near-infrared (NIR), completed with similar high-spatial resolution data in the mid-infrared (VLT/VISIR), optical (HST), radio (VLA) and X-rays (Chandra).
Based on ~30 young clusters we obtained, for both galaxies, median spectral energy distributions (SEDs) at high-spatial resolution, which are characterized by a maximum at 20 μm and a gentle bump in the 1-2 μm range. The latter, absent in lower spatial resolution data, can be well reproduced by considering an important contribution of very young stellar objects to the NIR, thus associated with the presence of hot dust surrounding the protostars.
With ALMA we will be able to constrain the templates in the mm/submm range at subparsec scales. Star formation rates and ages for each cluster can be derived using free-free emission and hydrogen recombination lines, whereas the CO lines trace the cold dust component, and thus their masses.

Chemical modeling of the interstellar medium (ISM) in external galaxies: the case of M82

Fuente, A. (OAN, Spain), García-Burillo, S., Usero, A., González-García, M.

The detection of molecules different from CO in external galaxies started more than two decades ago with the advent of large millimeter telescopes (e.g. IRAM 30m). Since then, most common molecules in our Galaxy (CS, HCN, HCO+...) and even some unstable (CO+,HOC+) or low abundant (SiO) compounds have been detected in nearby galaxies. More recently some of these molecules (CH, HCN, HCO+) have also been detected towards the more distant high-z galaxies. The forthcoming high sensitivity and

angular resolution telescopes (e.g. ALMA) will surely increase the number of molecules detected in external galaxies and the importance of chemistry in extragalactic research. Chemistry has been a useful tool for the understanding of the interstellar medium (ISM) in our Galaxy. The observational study of some well-known Galactic patterns (Orion, Sgr B2) together with the increasing complexity of chemical models that now includes time-dependent effects and grain surface chemistry have allowed to trace the physical conditions of small regions that should remain otherwise unresolved with the current instrumentation. These are the cases of the thin layers of hot gas in the HII/molecular cloud interface (photon-dominated regions), the hot and compressed gas left behind a shock front (shock chemistry), or the rich in complex molecules regions formed around young stars when grain mantles are evaporated (hot cores). The extrapolation of this observational and chemical modelling knowledge to extra-galactic research is, however, not straightforward. The dimensions, mass and energetics involved in some external galaxies (starbursts, active galactic nuclei) make them different from any Galactic reference. In addition to the environment conditions, the different metallicity is also expected to drive a different molecular chemistry. Thus, extragalactic patterns and a dedicated chemical modelling are required for the correct interpretation of the observations. Thus far, M82 is one of the most beautiful examples of how chemistry can help to the full understanding of the ISM in an external galaxy and the reverse, how the extragalactic research can push forward the chemistry comprehension. Our early HCO interferometric map using the PdBI showed that the M82 nucleus is a giant photon-dominated region (PDR) of 650pc size. The subsequent chemical study (CN, HCN, HOC+, CO+) allowed us to put some restrictions to the ISM physical conditions and cloud properties. Because of the wealth of data and its successful chemical modelling, M82 has become the prototypical extragalactic PDR and a reference for the study and interpretation of the most distant galaxies.

AGN feeding: a molecular line perspective

García-Burillo, S. (OAN, Spain)

The study of the content, distribution and kinematics of interstellar gas is a key to understand the origin and maintenance of nuclear activity in galaxies. The processes involved in AGN fuelling encompass a large variety of spatial and temporal scales. Probing the gas flow from the outer disk down to the central engine of an AGN host, requires the use of specific tracers of the interstellar medium adapted to follow the change of phase of the gas as a function of radius. As most of the neutral gas in galactic nuclei is in the molecular phase, low-J rotational transitions of carbon monoxide (CO) are the best choice to undertake high-spatial resolution (<1") interferometer mapping of the central kiloparsec disks of AGNs. Finding ``smoking gun" evidence for AGN fuelling is challenging, perhaps because of the short-lived nature of the mechanisms responsible. Whereas their capabilities will be surpassed by ALMA, current mm-interferometers can already provide relevant information on scales which are critical for the process of angular momentum transfer in fuelling the AGN, however. Furthermore, the use of more specific molecular tracers of dense gas can probe the feedback influence of activity on the chemistry and energy balance in the interstellar medium of nearby galaxies.

FIR continuum+line properties of nearby galaxies as local benchmark for future ALMA studies at high redshift

Gil de Paz, A. (UCM, Spain)

The unprecedented sensitivity of ALMA should allow us to identify galaxies at very high redshift (z>5) through their redshifted FIR continuum and line emission and to map them at these wavelengths. In this talk we will summarize our current understanding on the spatial distribution of the dust (and its properties) in nearby star-forming galaxies. We will also discuss on the delectability of redshifted [CII] 158micron emission with ALMA and on the current efforts to provide a calibration of this line as a measure of the SFR in galaxies using soon-to-come observations of nearby galaxies by PACS onboard Herschel.

ARTIST: Adaptable radiative transfer innovations for submillimeter telescopes

Girart, J. M. (CSIC-IEEC, Spain), Jørgensen, J. K., Vlemmings, W., Hogerheijde, M., Bertoldi, F.

ARTIST is an accepted project of the ASTRONET First Joint Call for Proposals: "Common Tools for Future Large sub-mm Facilities". It is a collaborative task between the Argelander Institute for Astronomy, Leiden University and the ICE (CSIC). It is aimed to develop a next generation model suite for comprehensive multi-dimensional radiative transfer calculations of the dust and line emission, as well as their polarization, to help interpret observations with these groundbreaking facilities. In this talk I will describe the project and give some possible applications of ARTIST for ALMA extragalactic observations.

SAFARI, an European far-IR instrument for SPICA in the ALMA context

Goicoechea, J. (CAB-CSIC, Spain), Isaak, K.

The far-IR (FIR) spectral window plays host to a wide range of both spectroscopic and photometric diagnostics with which to probe the very local and the very distant Universe. These include some of the key atomic and molecular cooling lines for warm gas (100-1000 K), the peak of the thermal emission from dust at temperatures characteristic of the ISM, as well as the water vapour/ice features and red-shifted PAH bands. Most of these FIR features can not be observed from ground-based telescopes but play a critical diagnostic in a number of key areas of astrophysics: they provide discrimination between AGN and starburst regions in galaxy evolution; they trace dust-obscured environments in galactic nuclei, and they provide clues to the chemical evolution of the ISM in both our own and more distant galaxies. The proposed Japanese-led MIR/FIR mission, SPICA (~2017), with its 3.5m cooled mirror will be the next step in sensitivity after Herschel. SPICA has been recently selected to go to the next stage of the ESA Cosmic Vision 2015-2025 process. In this contribution we will summarize the design concept behind SAFARI: an imaging FIR spectrometer covering the ~30-210um waveband; we also highlight some of the exciting science questions that it will be possible to address with SPICA/SAFARI, and that will complement ALMA capabilities in the millimeter and sub-millimeter domains.

Synergies btween ALMA and SKA

Guirado, J. C. (Univ. Valencia, Spain)

ALMA will give a huge improvement in sensitivity and resolution at millimeter and submm-wavelengths. Likewise, the Square Kilometre Array (SKA) is the future centimeter- and meter-wavelength telescope with a sensitivity about 50 times higher then present instruments. Since the initial conception, ALMA and SKA are complementary in frequency coverage, and comparable in maximun resolution. Both instruments can work together to study a variety of astronomical phenomena. In this talk, we will identify astrophysical scenarios where the synergy ALMA/SKA may optimize the scientific output.

Millimeter and Submillimeter Interferometry in preparation for ALMA

Ho, P. T. P. (CfA, USA/ ASIAA, Taiwan)

With ALMA approaching operations in the next few years, the various mm and submm interferometers must prepare the fist science targets. Prototypical objects should be studied in depth in order to predict what could be done when the sensitivity is greatly increased. Fainter phenomena can be studied in order to predict their feasibility for discovery science. Small surveys can be made in order to define the size scale and depth for new ALMA surveys. Finally, targets in the south should be prepared for interferometry. The SMA is preparing specifically for higher frequency studies in the ALMA era.

Single-dish FIR to millimeter-wavelength facilities in the era of ALMA

Hughes, D. (INAOE, México)

The advantage of combining wide-field imaging with fast mapping speeds at intermediate resolutions (3-20 arcsecs), and targeted follow-up of individual sources or selected regions with observations providing 10 milli-arcsecond to sub-arcsec resolution is well-understood at optical, IR and radio-wavelengths.
Studies that offer a deep physical insight into the nature of planet-formation in dusty disks around nearby stars, the evolution of stars within the cores of their extended molecular clouds, and the formation of the first galaxies and large-scale structure, amongst others, all require a mix of high sensitivity and image-fidelity over a wide-range of spatial scales. In the coming decades, millimeter astronomy will, for the first time, benefit from the same opportunity to combine large single-dish and interferometric telescopes. In the context of ALMA, I will summarise the continuum and spectral-line capabilities of current and future single-dish telescopes that operate at FIR to millimeter wavelengths, using examples to illustrate the complementary observations that can be made with to understand the formation and evolution of structure in the local and distant universe.

Star Formation Laws In Nearby Galaxies Like M51 and M33

Kramer, C. (IRAM, Spain)

The mechanisms governing the star formation rate in spiral galaxies are not yet clear. Two empirical laws describe star formation in galaxies. Firstly, stars are often observed to form efficiently only above a critical gas surface density which appears to be determined by the Toomre criterion for gravitational stability. Secondly, a tight relation has been found between the star formation rate and the surface density of the total gas, i.e. the molecular and atomic gas, the Schmidt law. I will address recent studies of the star formation laws derived from detailed maps of nearby galaxies. I will focus my talk on M51. This nearby, almost face-on, and interacting galaxy M51 offers an excellent opportunity to study at relatively high spatial resolutions the local star formation laws by combining CO, HI data to trace the molecular and atomic gas component, dust emission data and radio continuum data to trace the star forming activity, and K-Band data to trace the stellar mass content. The potential of future studies with Herschel and ALMA will be addressed.

MADCUBA: Tools for Advanced Data Cube Analysis

Martín Pintado, J. (CAB-CSIC, Spain), Martín, S., Asensio, J. L., Sánchez., E.

Large sub-mm facilities will routinely generate very large data cubes with huge scientific potential to tackle key problems of modern astrophysics. No existing tools efficiently deal with such large data cubes. We present the development of user-friendly tools and the required additional infrastructure to enable efficient high level data cube analysis. The entire infrastructure will be combined in Madrid Data Cube Analysis (MADCUBA) to generate high level scientific products that allow users to go from data cubes to their interpretation in terms of physical quantities.

Spectral line surveys in the ALMA era

Martín Ruiz, S. (CfA, USA)

The increasingly larger bandwidth of current instruments has allowed us to explore chemical composition of the ISM in the central few hundred parsec of galactic nuclei. In this context, unbiased spectral line surveys have been proven as powerful tools to understand the main heating mechanisms of the ISM. These surveys provide valuable information on the nuclear power sources within these heavily obscured environments.
I will overview the latest results concerning line surveys being carried out in various mm and submm telescopes around the world.
It will be discussed what can be expected from ALMA and the study of the chemical composition of nearby and high-z galaxies.

Hot spots in radio galaxies

Orienti, M. (IAC, Spain)

Hot spots are compact and luminous regions located in the outermost part of powerful radio sources. These remote regions are considered the "working surface" of supersonic jets in which kinetic energy is dissipated into the acceleration of relativistic particles. Optical emission of powerful radio hot spots has been rarely detected, since high-energy electrons, responsible for the optical photons, have short radioactive lifetime.

However, in low-power radio hot spots, where energy losses are less severe, an unprecedented high optical detection rate has been found.
I will discuss the properties of radio hot spots and the role that ALMA will play in constraining the acceleration mechanisms and the physical conditions occurring in these regions.

An IR perspective on the assembly of galaxies at z>1 and the role of AGN: from Spitzer to ALMA

Pérez-González, P. (Univ. Complutense Madrid, Spain), Rieke, G. and MIPS Team, Alonso-Herrero, A.,

We will present the main results of our research about the assembly of galaxies at $z<4$ based on the data obtained by the deepest Spitzer surveys carried out with its two imagers (IRAC and MIPS) in the first 6 years of the mission. These data in the mid- and far-IR have allowed us to obtain unprecedentedly robust estimations of the obscured SFR and the stellar masses of distant galaxies. Analyzing SFR and stellar mass functions in several redshift bins at $0<z<4$, we have found that galaxies formed following a downsizing scenario, with the most massive systems assembling early in the lifetime of the Universe and very quick (i.e., with very high star formation efficiencies, and a significant amount of obscured starbursts), while less massive systems assembled later and/or more slowly. However, Spitzer data have left several open questions that still hamper our current understanding about the formation and evolution of galaxies. I will discuss three of these results and how ALMA can lead to a more robust and detailed (with higher spatial resolution and depth) characterization of how galaxies formed in the early Universe ($z>1$): (1) the mid-to-far IR colours of galaxies evolve with redshift, departing considerably from the typical values observed in the local Universe, specially at $z>1.5$-2.0; (2) the IMF might not be universal time, evolving to a top-heavy IMF at $z>1.5$; (2) obscured AGN may be ubiquitous in high-z galaxies, playing a significant role in the downsizing scenario.

The GTC in the world of ALMA

Rodríguez Espinosa, J. M. (IAC, Spain)

The GTC 10.4m telescope should be starting operations just a few weeks after this meeting. New opportunities will open to the GTC community when ALMA begins operations a few years later. In my talk I will briefly show the status of GTC, discuss possible synergies between GTC & ALMA, and alert the GTC community of the excellent opportunities that the GTC offers to start preparing programmes for ALMA observations.

Cosmology with ALMA using the Sunyaev-Zeldovich effect

Rubiño, J. A. (IAC, Spain)

ALMA will be able to detect the cosmic microwave background (CMB) anisotropies at arcsecond angular scales, allowing the characterization and separation of some of the secondary effects in the CMB, such as the Sunyaev-Zeldovich and Ostriker-Vishniak effects. Those observations could probe the reionization epoch and the nature of the dark energy.

In this talk I will focused on the Sunyaev Zeldovich effect (SZE) associated to high redshift clusters and proto-clusters of galaxies. ALMA will allow to study those systems in detail, providing valuable information about their inner structure. In addition, ALMA will provide unique information about the kinetic component of the SZE.

IRAM node: Support for Spanish astronomers

Salome, P. (IRAM, France)

Strong interactions and mergers: the role of molecular gas in the evolution of ULIRGs, PRGs and QSOs

Sanders, D. (Univ. Hawaii, USA)

Studies of complete samples of ultraluminous infrared galaxies (ULIRGs), powerful radio galaxies (PRGs) and optically selected quasi-stellar objects (OSOs) in the local universe ($z < 0.3$), clearly show that strong interactions and mergers of molecular gas-rich spirals are responsible for the great majority (and perhaps all) of these objects. High resolution (<0.1") submillimeter observations will be critical for a proper understanding of the important role played by the dense molecular gas in fuelling both starburst and AGN activity in these objects. I will review existing mm- and sub-mm interferometry observations of (U) LIRGs selected from the IRAS RBGS and discuss future plans for observations with ALMA.

Evolution of galaxies and AGN with their environmental connections at high z

Scoville, N. (CalTech, USA)

ALMA will provide unique capabilities to understand the formation and buildup of the highest mass / most luminous galaxies and AGN in the early universe.I will summarize present observations in this area and the future investigations with ALMA and other future instruments.

The ALMA Project: status and progress towards science operations

Testi, L. (ESO, Germany)

The Atacama Large Millimeter/submillimeter Array (ALMA) has been designed and is being built to allow us to study in detail the formation of stars and planetary systems in the solar neighborhood, the evolution of the insterstellar medium of galaxies in the Universe and to provide images at millimeter wavelenghts with angular resolution and fidelity similar or better than the current generation of space observatories and adaptive optics fed large optical/infrared telescopes. ALMA is a global partnership between Europe, North America and East Asia to build world leading observatory at millimeter wavelengths in the coming decades; ESO is leading the European effort in this project. In this talk I will describe the scientific goals and capabilities of ALMA, the current status of the construction and the plans for Early Science and Full Science operations.

Resolving the drivers of molecular gas chemistry in starburst and AGN galaxies

Usero, A (OAN, Spain), García-Burillo, S., Fuente, A., Graciá-Carpio, J.

In the last years, observations of molecular (sub)millimetre-wave lines have resulted in the first detailed characterization of the molecular gas composition in some starburst and active galaxies. The differences found between the studied objects have been chiefly ascribed to an uneven impact on the interstellar medium of the feeding and

feedback mechanisms associated with the starburst and Active Galactic Nuclei (AGN) episodes. Several attempts to correlate starburst/AGN activity and evolution with molecular gas composition have followed. Yet low numbers of galaxies are suitable for these works, due to some limitations of the current facilities operating at (sub)millimetre wavelengths. Among those limitations that will be comfortably overcome by ALMA, is spatial resolution. To illustrate the potential of high spatial resolution studies of the molecular gas chemistry in galaxies, we review several works based on radiointerferometric observations. The spatial resolution achieved by means of these techniques (~few tens of pc in nearby objects) allows us to pinpoint the emission of the different molecular tracers in a galaxy. This facilitates the identification of the drivers of the gas composition and allows us to resolve the different kinds of molecular chemistry that may coexist in a single object. Interferometric observations have also made the study of molecular chemistry in high-redshift galaxies possible, yet in a very few objects so far. These observations are ushering in a new field that is bound to be deeply explored after the arrival of ALMA.

Alma-3d: Analysis, visualization and VO tools for datacubes

Verdes-Montenegro, L. (IAA-CSIC, Spain), Ruiz del Mazo, E., Santander-Vela, J.d.D, Espigares, V., Van der Hulst, T.

Full exploitation of ALMA capabilities relies on an efficient analysis of a significant volume of datacubes, including modelling of velocity fields, extraction of rotation curves or multi-line analysis, among others.The scientific goals of the AMIGA project (http://www.iaa.es/AMIGA.html) are also based on intensive analysis of 3D data for galaxies. This, combined with the expertise developed in our group during the last years on Virtual Observatory (VO) aspects at radio-wavelengths, motivated us to start a project to develop a new VO compliant package in collaboration with the Kapteyn Institute, including present core applications in Groningen Image Processing System (GIPSY) and new ones based on use cases elaborated in collaboration with advanced users. One of the main goals is to provide local interoperability between GIPSY (visualisation and data analysis) and other VO tools. In addition, the connectivity with the VO environment will provide general access to 3D data (ALMA) VO archives. In this talk we will present such project and illustrate how can it help extragalactic astronomers in the exploitation of ALMA data.

A general view of extragalactic projects with ALMA

Wiklind, T. (STSCI, USA)

ALMA will revolutionize extragalactic studies in the millimeter and submillimeter wavelength regime. The large increase in both sensitivity and angular resolution compared with existing facilities will allow detailed studies of the molecular gas content and dust content of both nearby and distant galaxies. For the most distant galaxies ALMA will also be able to study the ionized gas component through fine-structure lines. ALMA is not, however, a survey instrument and will rely on source selection from other surveys.
I will discuss the scientific potential of ALMA regarding extragalactic observations, with a special emphasis on the synergy between ALMA and existing and planned UV/optical deep surveys.

Studying stellar mass build up in high redshift galaxies using ALMA

Yun, M. (UMASS, USA)

One of the defining goals for ALMA is to detect spectral line dense gas tracers like CO or CII in normal Milky Way like galaxies out to a redshift of z~3. This means ALMA will enable us not only to detect and study massive young "monster" galaxies (ULIRGs, SMGs) forming in the early universe in great detail but also to investigate how normal galaxies commonly seen in the present universe have gained mass and evolved to their present state. I will summarize what is known about the dusty starburst phenomenon in the present and early universe and discuss how ALMA can be used to complete the panchromatic view of the galaxy formation and mass build-up, bridging the knowledge gap presently driven by wavelength dependent limitations.

ABSTRACTS OF POSTER CONTRIBUTIONS

Structure and properties of dense molecular gas in the nucleus of starburst galaxies

Aladro, R. (IRAM, Spain), Martín-Pintado, J., Mauersberger, R., Martín. S.

We present a multitransition study of three molecular tracers of dense gas toward the nucleus of two nearby starburst galaxies, NGC253 and M82, which are believed that the heating is dominated by shock waves and photodissociation regions (PDRs) respectively. Through the multiline analysis of these molecules and assuming both LTE and Large Velocity Gradients (LVG) approximations, we are able to distinguish the density structure and chemical properties of the gas, which clearly differs from one galaxy to the other. While NGC253, CS and HC3N trace the same three gas components with different densities, in M82 CS traces two density components and only one in the case of HC3N. On the other hand, CH3CCH traces uniform density gas in both galaxies. These results point out a possible relationship between the density structure and the stage of evolution of the galaxies. We find that M82, a more evolved starburst than NGC253, seems to have a rather uniform density structure and chemical composition than NGC253.
In addition, CH3CCH also shows a high relative abundance of ~107 in M82, which is two orders of magnitude larger than that found in NGC253. This is surprising since was expected a lower abundance of CH3CCH in PDR regions, due to the fact that this molecule is supposed to be easily photodissociated. ALMA will provide the resolution and the sensitivity to resolve the different density components and derive directly the abundance variation of a larger number of molecules in those density components.

Toward gain calibration in ALMA: fast-switching tests in the SMA

Martínez-Badenes, V. (IAA-CSIC, Spain), Espada, D.

In the millimeter/submillimeter range, fluctuations the water vapour content in the troposphere are found to be one of the worst enemies of aperture synthesis observations, limiting the spatial resolution and being responsible of loss of coherence in the radio signal. In order to improve the results of the observations, the fast-switching technique tries to minimize this effect trough fast and successive cycles between calibrator and source. Here we present the results of the fast-switching tests carried out at the Submillimeter Array (SMA) in order to shed light into the optimization of the calibration cycle as a function of different atmospherical conditions. We have found that, under relatively good weather conditions, the application of fast-switching with calibration cycles of a few minutes slightly improve (~15%) the image-to-noise ratio in the image plane with respect to standard calibration time of 20-30 minutes, confirming previous findings that mnost of the fluctuations must be shorter than 2 minutes under normal conditions in the SMA site and baseline range from 20 to 200 meters.

Molecular gas disk in the center of nearby elliptical radio galaxies?

Ocaña Flaquer, B. (IRAM, Spain) et al.

It was thought that early type galaxies have no molecular gas, but Wiklind et al 1986 found little molecular gas in this type of galaxies. We have performed a study of CO(1-0) and CO(2-1) in a sample of nearby radio galaxies, hosted in elliptical galaxies, selected only on the basis of their radio continuum. We find a median value of the molecular gas mass of 1x10^8 Msun, a low value compared with other samples selected for their FIR fluxes and with galaxies in interaction (Evans et al 2005, Bertram et al 2007 and Mazzarella et al 1993). They find in average a larger content of the molecular gas. In our sample the galaxies detected in both lines show a CO(2-1)-to-CO(1-0) line ratio of about 2.2. According to Combes et al. 2007 the ratio should be higher than one for galaxies that are a point source.
From the HST images (Mertel et al 1997) we see the dust in some of the galaxies (e.g. 3C31) and they do not appear to be a point source, although the size of the galaxy seems to fit into the IRAM-30m telescope beam. We believe that mapping these galaxies with ALMA at the high-J CO transitions will give us a close insight of this subsample of galaxies in order to let us draw a more accurate conclusion about the physical conditions of the gas in the center and the possible interaction of the ISM with the AGN.

Herschel M33 extended survey (HERMES)

Quintana-Lacaci, G. (IRAM, Spain) et al.

The morphology and dynamics of the galaxies of the local universe are mainly dominated by the stellar objects that lie within themselves. Therefore, reaching a better understanding of the regions where these stars are formed is fundamental to understand the properties of the galaxies.
Although, a large number of studies have been carried out on individual star forming regions in the Milky Way and in other galaxies, we still lack of a complete view on the chemical and physical processes that drive the star formation and their dependence on local conditions as well as on properties related to large scale features of the host galaxy.

The HERMES project will combine the capabilities of the far-infrared instruments HIFI, PACS, and SPIRE onboard Herschel space observatory and the properties of the Local Group galaxy M33 to obtain this global view.
M33 is the optimal target for this project, since it is a nearby regular disk galaxy, not as inclined as Andromeda galaxy, and rich in gas. Observing a extended strip along the major axis of M33 will allow us to study the different gas phases of the interstellar medium, as well as its life cycle and thermal balance. Finally this will help us to trace the formation of molecular clouds and stars and relate it to the different galactic environments.
The results obtained will provide a new understanding on the properties of M33, setting the basis for the interpretation of the features found in other galaxies.

Disk-Halo interface: Studying the "foot point" of two Galactic Molecular Loops as a template for external galaxies

Riquelme, D. (IRAM, Spain) et al.

Studies of external edge-on galaxies provide an excellent bird's eye view of galaxy disk-halo interface without some of the confusion which is present in the Milky Way. Such observations require high resolution and very good signal-to-noise that we will obtain with ALMA. The spatial resolution of the existing telescope does not allow to study the physical processes which dominate the disk-halo interaction. Studies of selected regions of the Milky Way provide the only possibility to study in detail the role of magnetic loops, galactic winds, and gas accretion in the disk-halo interaction.
Fukui et al. (2006), in their CO(1-0) observations toward -12<l<12 and -5<b<5, found huge structures in loops shapes and propose the existence of "giant molecular loops" (huge loops of dense molecular gas with strong velocity dispersions) at the Galactic center formed by a magnetic buoyancy caused by a Parker instability. According to Fukui's model, the gas of the loops would flow down their sides, along the magnetic field lines, and join with the gas layer of the Galactic plane, generating shock fronts at the ``foot points" of the loops which is supported by broad velocity features of 40 to 80 km/s.
In this poster we present additional evidence of shocked gas at the ``foot points". Riquelme et al.(2009, in prep.) present a survey of the Galactic center region in HCO+(1-0), H13CO+(1-0), and SiO(2-1)lines toward -5.75<l<5.625 and -0.6875<b<1.35425. They find an enhancement of the SiO emission at the ``foot point" zones with respect to HCO+, which indicates shocks presence, supporting the Fukui's model. Resent high spatial resolution (38") observations of 3mm lines, carried out with Mopra telescope have confirmed our first results. The SiO emission shows structures at small scales which indicate the presence of shocks (Martín-Pintado et al 1992, 1997) in clumps of the foot points

Hα imaging of JCMT Nearby Galaxies Legacy Survey targets

Sánchez Gallego, J. R. (IAC, Spain), Knapen, J. H.

This project aims to study the interplay between gas, dust, and star formation in local galaxies. It will use the sample and data of the JCMT Nearby Galaxies Legacy Survey, which is a JCMT legacy program that has been awarded 200h of SCUBA2 and HARP-B observing time by the JCMT board, with observations now ongoing. We will concentrate on obtaining and analysing observations of the current massive star formation in the sample galaxies. This will be done in the first instance with Hα

imaging of all our 155 sample galaxies. From this, we will (1) determine the overall rate of star formation, important baseline information to constrain any SED interpretation and modelling; (2) determine the morphology of the massive star formation; and (3) analyse the Schmidt- Kennicutt law, which relates gas density and star formation activity in galaxy discs through a simple power law, and which we can study in unprecedented

Integrating the ALMA Science Archive in the VO

Santander Vela, J. d. D (IAA-CSIC, Spain), et al.

One of the prerequisites for the ALMA Science Archive (ASA) is that it should be made Virtual Observatory (VO) compliant. At the AMIGA group, we are starting to participate in the VO-compliance of the ASA in collaboration with the ASA team, by studying which are the prioritised services the ASA will provide, how do they map to existing VO Data Access Layer services, and the high-level mapping of the ALMA Science Data Model to existing VO data models.

Panchromatic analysis of the star formation processes in M33

Verley, S. (IAA-CSIC, Spain/UNAM, México) et al.

The spiral galaxy M33 belongs to the local group and allows us to study star formation processes with great accuracy. The Spitzer telescope reaches spatial resolutions of the order of some parsecs and reveals the interactions between young stars and the interstellar medium. A detail analysis focussed on the typical colours of discrete sources such as HII regions, planetary nebulae and supernovae remnants. Also, we estimated the star formation rate in M33, using Halpha, UV and IR tracers. We tested the radial Kennicutt-Schmidt law, finding that the star formation shows a better correlation with the molecular gas than with the atomic or total gas content of the galaxy.