

# Impact of ALMA on Spanish Extragalactic Astronomy

held at the Instituto de Astrofísica de Andalucía, Consejo Superior de Investigaciones Científicas (CSIC), Granada, Spain, 11–13 February 2009

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In order to prepare the Spanish extragalactic community for the impact of ALMA science, a meeting with participation of non-radio astronomers was held to introduce the ALMA capabilities and to explore the synergies with optical and infrared facilities.

The Atacama Large Millimeter/submillimeter Array (ALMA) will be an extraordinarily complex and powerful instrument for the study of the (sub)millimetre window in the extragalactic field. A panchromatic approach to its exploitation will be a key to the success of the project and therefore the active involvement of those outside the radio astronomy community is highly desirable. To this purpose, more than 70 Spanish extragalactic astronomers from 13 Spanish research centres, either already involved or potentially interested in the ALMA project, met in Granada, together with some invited international specialists in the field. The scientific organising committee, chaired by Lourdes Verdes-Montenegro and Josefa Masegosa from the Instituto de Astrofísica de Andalucía (IAA-CSIC), aimed at involving most of the Spanish extragalactic community in ALMA, with a strong contingent of non-radio astronomers. The scientific programme was designed to exploit the complementarities between the radio and non-radio communities, exploring how ALMA could enhance the research of those astronomers currently less familiar with the project, as well as how synergies with other wavelengths could benefit the radio astronomers. A total of 36 talks were presented at the workshop, while eight young researchers contributed with posters describing their PhD thesis work in the context of ALMA. The contributions can be consulted on the conference web page<sup>1</sup>.

## Introduction to the ALMA project

This first session was opened by Jesús Martín Pintado, representing the RIA (Red de Infraestructura en Astronomía) ALMA working group, and by the European ALMA Project Scientist Leonardo Testi, who presented the status of the ALMA project. Support activities for Spanish astronomers by the IRAM node were presented by Philippe Salomé and complemented by the talks from the three Spanish groups developing applications to exploit ALMA. In particular, Jesús Martín Pintado introduced MADCUBA (Madrid Data Cube Analysis), a tool for advanced datacube analysis, José Miquel Girart presented ARTIST (Adaptable Radiative Innovations for Submillimeter Telescopes), a next-generation model suite for comprehensive multi-dimensional radiative transfer calculations of dust and line emission, as well as their polarisation, while Lourdes Verdes-Montenegro presented the development of a new VO-compliant GIPSY package fully compatible with ALMA datacubes. Tommy Wiklind closed this first section with a vision of representative scientific cases for ALMA, explaining how the large increase in both sensitivity and angular resolution, compared with existing facilities, will allow detailed studies of the molecular gas and dust content of both nearby and distant galaxies. For the most distant galaxies ALMA will also be able to study the ionised gas component through fine-structure lines.

## Nearby galaxies — detailed studies

The topic was reviewed by Elias Brinks, with particular emphasis on the prediction of the star formation rate density, from the THINGS (The H<sub>I</sub> Nearby Galaxy Survey) project. The study of the content, distribution and kinematics of interstellar gas is a key to understanding the origin and maintenance of active galactic nuclei (AGN). Santiago García-Burillo provided a complete molecular line perspective of AGN feeding, while Sergio Martín presented the strength of unbiased spectral line surveys to understand the main heating mechanisms of the interstellar medium. The information that can be obtained from maser lines of water vapour to trace the gas around

AGNs was discussed by José Cernicharo. ALMA will allow high excitation maser lines of water vapour to be observed in the submillimetre domain.

## Environment

The long-standing debate of “nature versus nurture” was revisited by David Sanders. He discussed plans for observations with ALMA that will be critical for a proper understanding of the important role played by dense molecular gas in fuelling both starburst and AGN activity in ultraluminous infrared galaxies, powerful radiogalaxies and optically selected quasars in the local Universe, most of them strongly interacting. Daniel Espada emphasised the bias of most studies on molecular gas towards interacting systems, due to the lack of sensitive instruments in the millimetre/submillimetre range, describing how the multi-wavelength study of a large sample of isolated galaxies performed by AMIGA (Analysis of the Interstellar Medium of Isolated GALaxies) project will contribute towards establishing a reference for future ALMA environmental studies.

## High-z systems and cosmology

The unique capabilities of ALMA, that will further understanding of the formation and build-up of the highest mass/most luminous galaxies and AGN in the early Universe, were emphasised by Nick Scoville, who summarised the current observations in this area, including the COSMOS project. Both Min Yun and Pablo Pérez-González emphasised how ALMA could complete the panchromatic view of galaxy formation and mass build-up, bridging the knowledge gap presently caused by wavelength-dependent limitations. The current understanding of the spatial distribution of the dust in nearby star-forming galaxies was summarised by Armando Gil de Paz, who discussed the detectability of redshifted [C II]150- $\mu$ m emission with ALMA, as well as current efforts to provide a calibration of this line as a measure of the star formation rate in galaxies using Herschel.

ALMA will be able to detect Cosmic Microwave Background (CMB) anisotrop-

ies at arcsecond angular scales, allowing the characterisation 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 reionisation epoch, the nature of the dark energy and allow the study of high redshift galaxy clusters and protoclusters, as explained by José Antonio Rubiño.

### Preparing for ALMA — synergies

The final session of the conference was designed explicitly to promote synergies between the radio and non-radio astronomers, with the aim of preparing for challenging projects with ALMA. Survey projects with the strong involvement of the Spanish community, which would provide the best targets for ALMA studies, were reviewed. Narciso Benítez presented preliminary results from the ALHAMBRA (Advancer Large Homogeneous Area Medium-Band Redshift Astronomical) survey and introduced the future Javalambre/PAU (Physics of the Accelerating Universe) survey, which will cover the full northern sky with 40 medium band filters. Jordi Cepa summarised some of the surveys proposed by the OSIRIS instrument at the 10.4-metre GranTeCan (GTC) telescope, Marc

Balcells presented the near-infrared spectroscopy of  $z = 1\text{--}2.5$  galaxies to be performed by the GOYA (Galaxy Origins and Young Assembly) project with the GTC/EMIR instrument and Nieves Castro-Rodríguez reviewed Herschel and Spitzer cosmological surveys.

With ALMA approaching operations in the next few years, it is clear that the various millimetre and submillimetre facilities must be already preparing the first science targets. Single-dish far-infrared to millimetre facilities were reviewed by David Hughes, while Paul T. P. Ho focused on the interferometric ones, showing how the SubMillimeter Array (SMA) is preparing specifically for higher frequency studies in the ALMA era. Antonio Alberdi presented the sensitivity improvements that could be obtained if a phased array with a large number of antennas working at millimetre and submillimetre wavelengths like ALMA is used as an element of the VLBI array, while José-Carlos Guirado identified various scenarios where the synergy between ALMA and the Square Kilometre Array (SKA) may optimise their scientific output, as complementary instruments in frequency coverage and maximum resolution. Javier Goicoechea summarised the design concept behind SAFARI, a European imaging far-infrared spectrometer for the

SPICA mission covering the 30–210  $\mu\text{m}$  band, and highlighted science questions that it will be possible to address with SPICA/SAFARI that will complement ALMA capabilities.

Complementarities between ALMA and existing forthcoming X-ray observatories, which together can help to disentangle the contribution of star formation and supermassive black hole growth to the bolometric luminosity of AGN and luminous infrared galaxies, were presented by Francisco Carrera. Special interest was raised by the talk by José-Miguel Rodríguez-Espinosa, who showed the status of the Spanish GTC telescope, which has just entered operations, alerting the community to the excellent opportunities that the GTC offers to start preparing programmes for ALMA observations, as well as providing instrumental possibilities to follow up ALMA discoveries.

### Acknowledgements

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### Links

<sup>1</sup> <http://riastronomia.es/opencms/opencms/Workshops/R20081201.html>

Report on the ESO Workshop

## E-ELT Design Reference Mission and Science Plan

held at ESO Garching, Germany, 26–28 May 2009

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ESO hosted a dedicated workshop on the European Extremely Large Telescope (E-ELT) Design Reference Mission (DRM) and the Design Reference Science Plan (DRSP). The main aim of this three-day workshop was to exchange information and ideas with the scientific community on the status of the E-ELT and in particular on the development of the E-ELT science case through simulations.

Bringing together interested members of the community, various instrument study teams, members of the Science Working Group and the E-ELT Science Office at ESO, the focus of the workshop was to provide all interested parties with a platform for open exchange and critical assessment of the results of E-ELT performance simulations. In addition, the workshop provided an opportunity to present and discuss the E-ELT DRSP,