Report on the

ALMA Community Days: Early Science in Cycle 1

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Early Science operations began in September 2011 and ALMA is now more than half way through Cycle 0 and continues to gather data of remarkable quality. The first scientific results based on ALMA data include some very interesting findings and the number of ALMA publications is rapidly increasing. From the start of Cycle 1 at the beginning of 2013, the array will be offered to the astronomical community with enhanced science capabilities. The 2012 ALMA Community Days, summarised here, were held just a few weeks before the Cycle 1 proposal submission deadline and were designed to optimally prepare the European ALMA Community for Cycle 1 proposal submission.

ALMA, the Atacama Large Millimeter/submillimeter Array, is a global collaboration involving Europe, North America, East Asia and the host country Chile. The array is located on the Chajnantor Plateau in northern Chile at an altitude of 5000 metres, and when fully completed will comprise at least 66 high-precision antennas equipped to observe in the 30 GHz to 1 THz frequency range. ALMA has already started to produce transformational results from Early Science Cycle 0 programmes and will continue to be the world's leading observatory at millimetre and submillimetre wavelengths over the coming decades.

Until the end of construction (foreseen for 2013) ALMA is being operated in Early Science mode, where part of the time available is used for approved projects from the astronomical community, but completion and commissioning of the telescope take priority. Nearly 1000 observing proposals from the ALMA Community were received for Early Science Cycle 0, with an average oversubscription factor approaching ten. The highest ranked projects were scheduled for execution in the period from September 2011 through to the end of 2012. The science capabilities offered for Cycle 0 were rather limited, and comprised only sixteen 12-metre antennas, very limited spectroscopic flexibility, and baselines shorter than ~400 metres. Nevertheless, the data quality is already unmatched by similar (sub)millimetre facilities at the same angular resolution, and the first scientific publications clearly reveal ALMA's potential as construction nears completion.

In Cycle 1, the science capabilities offered to the community will be greatly enhanced compared to Cycle 0, and will include 32 antennas in the main 12-metre array as well as nine 7-metre antennas in the Atacama Compact Array (ACA) and two 12-metre antennas for the Total Power (TP) array. The frequency bands offered will be the same as in Cycle 0 – Band 3 (84–116 GHz, ~ 3 mm), Band 6 (211–275 GHz, ~ 1.3 mm), Band 7 (275–373 GHz, ~ 850 μm) and Band 9 (602–720 GHz, ~ 450 μm). More flexibility in combining continuum and high spectral resolution observations will be offered, and antenna baselines will reach up to ~ 1 kilometre.

In order to introduce the community to the Cycle 1 capabilities, a 2–3 day workshop was organised at ESO Garching with the aim of optimally preparing the European ALMA user community for proposal preparation in Cycle 1. The format was similar to that of the previous ESO ALMA Community Days held in April 2011 in preparation for Cycle 0 (see Randall & Testi, 2011). The first day of the workshop featured a variety of technical presentations giving an overview of the ALMA project, Cycle 1, and the user support available, as well as scientific presentations showing the first ALMA results. The rest of the workshop was dedicated to hands-on tutorials for the two main pieces of software used for proposal preparation: the ALMA Observing Tool (OT) and the ALMA Simulator Tools.

The ESO ALMA Community Days were part of a coordinated effort by the European ALMA Regional Centre (ARC) network to organise tutorials and webinars for users across the ESO Member States. We welcomed around 80 registered participants mostly from Europe, but also from as far afield as Australia. Interestingly, more than half the participants described themselves as novices in radio/submillimetre interferometry, indicating the broad interest in ALMA science. This fully supports the design goal of ALMA, which from the outset was conceived as a general community facility with strong emphasis placed on easy-to-use tools and widespread user support.

Technical information

Intended as an introduction to ALMA, the first morning's presentations started off with an overview of the ALMA construction status and the role of the European Science Advisory Committee (ESAC). This was followed by a recap of the first year of ALMA science observations and a breakdown of the science capabilities in Cycle 1.

The audience were then walked through the tools and processes important for observing with ALMA, starting with the ALMA Science Portal[1]. This web interface provides all the relevant information and software tools, and allows registered users access to the Helpdesk facility as well as information on their ALMA projects. The software tools pertinent to proposal preparation, the ALMA Simulator Tools and the ALMA Observing Tool, were introduced in preparation for the practical hands-on tutorials of the following days. While the simulators are used to get a feel for the image that ALMA will obtain of an object, taking into account the array configuration and time spent on source, the ALMA OT is used to prepare and submit the actual proposal. It captures all the technical information necessary to execute the observations and determines the setup of the array and the correlator for accepted projects. The proposal review process was then outlined, followed by a description of Phase 2 processes for highly ranked projects and the quality assurance and data delivery measures taken for executed observations in Cycle 1.

In the afternoon of that same day, the technical talks focused on user support provided by the European ALMA Regional Centre. The European ARC together with its counterparts in North America and East Asia presents the inter-

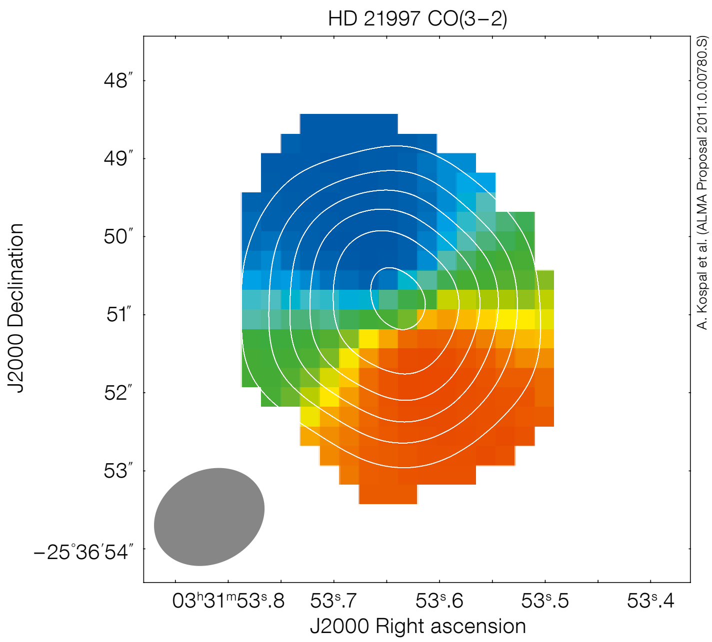

Figure 1. Map of the integrated CO line intensity (white contours) and the velocity field (background image) of the debris disc HD 21997 as seen by ALMA. The gray ellipse in the bottom left corner shows the synthesised beam.

face between the Joint ALMA Observatory in Chile and the astronomical community. It consists of a coordinating ARC hosted at ESO and seven ARC nodes distributed across Europe that between them provide a variety of services for European ALMA users, including face-to-face support, Phase 2 support, software development, data reduction and quality assurance, as well as the organisation of community events[2]. The ARC also runs the Helpdesk facility, which is the official point of contact for questions or comments specific to ALMA. Additional services offered by the ARC include the development of advanced data modelling software such as the ARTIST software, which was also presented.

The day of presentations was concluded by an outlook on the long-term development of ALMA science capabilities. In the medium term, it is expected that the array will be equipped with Band 5 (~ 187 GHz) receivers, originally developed in Europe as part of an EC-FP6 funded ALMA Enhancement Project. Another development within the next four years or so will be the capability to phase ALMA for incorporation into the mm-VLBI (millimetre-Very Long Baseline Interferometry) network (see the following report on the mm-VLBI workshop on p. 50). On a longer timescale, there are plans to equip the array with the low frequency Band 1 (~ 40 GHz) and Band 2 (~ 80 GHz) receivers. The possibility of supra-THz interferometry is also being studied, along with possible upgrades of the existing ALMA components.

First ALMA science results

Some spectacular scientific results based on both Cycle 0 projects and Science Verification ALMA data were presented by invited members of the European ALMA community in the science session. Matthias Maercker (ESO/Argelander Institut für Astronomie) presented an analysis of the shell structure of the asymptotic giant branch star R Scl (see front cover). The ALMA carbon monoxide (CO) observations allowed the mass loss of the star in the quiescent phase between thermal pulses to be reliably measured for the first time, leading to a reconstruction of the mass loss history in the ~ 2000 years since the last thermal pulse event.

Moving far beyond the realms of the Galaxy, Axel Weiss (Max-Planck-Institut für Radioastronomie) then described his redshift study of strongly lensed submillimetre galaxies from a Band 3 spectral scan. The use of ALMA as a stand-alone redshift pinpointer for submillimetre galaxies (alleviating the need for radio continuum cross-identification and subsequent expensive optical spectroscopy follow-up) was dramatically demonstrated. The quick ALMA spectral scans enabled the detection of at least one molecular line in 90 % of the submillimetre selected galaxies and two lines (allowing an unambiguous redshift determination) in 50 % of the sample. The emerging picture is a redshift distribution for submillimetre galaxies extending well beyond the z ~ 2–3 cutoff imposed by the selection effect caused by the centimetre radio continuum sensitivity in the past.

Agnes Kospal (ESA/ESTEC) was a little closer to home with her analysis of the molecular gas in the debris disc system HD 21997. ALMA's sensitivity makes it possible to observe the molecular gas abundance and kinematics in this young debris disc, allowing the study of the early phases of disc dissipation (see Figure 1). Switching back to extragalactic astrophysics, Cinthya Herrera (Institut d'Astrophysique Spatiale) combined ALMA Science Verification and VLT-SINFONI data to trace the Antennae galaxies merger. The combination of data from the two major ESO facilities in the infrared and submillimetre allowed the first detection of a compact and very massive molecular cloud, most likely a precursor for extragalactic Super Star Clusters. Moving to the Solar System, Thibault Cavalié (Laboratoire d'Astrophysique de Bordeaux) showed impressive maps of Saturn's 2011 storm as seen by Herschel and ALMA (see Figure 2). These data probe into the planetary atmosphere and can be used to constrain the physical and chemical models for gaseous giants.

Finally, an overview of the Science Verification data taken to date was presented, including the stunning Band 3 mosaics of the grand design spiral M100 and of the central regions of Centaurus A. The first released Band 9 data on IRAS 16293 were also shown.

Hands-on software tutorials

For the practical software tutorials the participants were split into two groups according to their experience with radio/submillimetre interferometry. While the advanced tutorials were designed to be more compact and last only one day, the

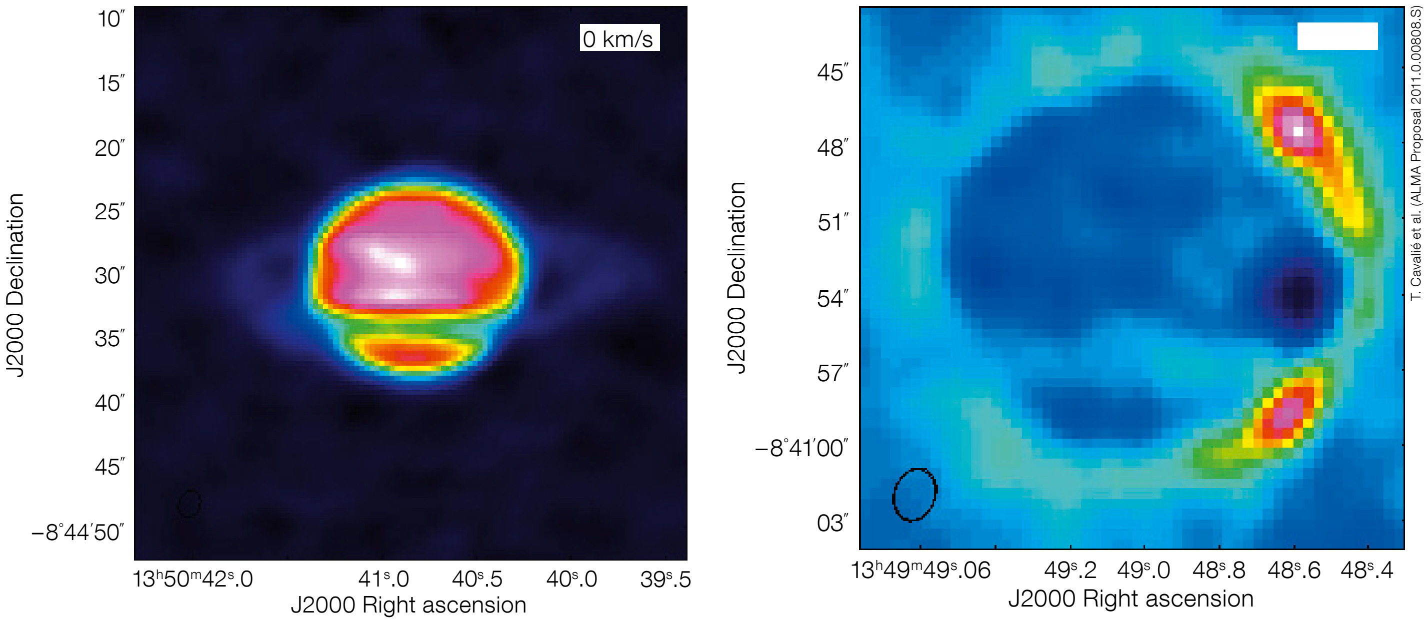

Figure 2. Left: ALMA continuum image of Saturn. The rings can also be seen (east and west of the planetary disc in emission, and in front of the planet absorbing part of its emission). The data were obtained in ALMA Band 6. Right: CO emission at the velocity of Saturn's Great Storm 2011 remnant (now a huge stratospheric warm vortex). While CO was detected in emission along the entire atmospheric limb, the vortex can easily be discerned as the brightest spot on the map (located at ~ 40 degrees northern latitude).

novice tutorials continued into the third day of the workshop, allowing more time. Each group was tutored in the use of both the Simulator Tools and the ALMA OT and started off with a short presentation/demonstration of the tool followed by periods of individual work assisted by tutors (see Figure 3). The novice tutorials included an extensive introduction to submillimetre concepts, the spectral setup and the basics of interferometry, whereas the advanced sessions focused more on the changes since Cycle 0. In total, around 60 participants chose to attend the tutorials.

The feedback received on the Cycle 1 ALMA Community Days was generally very positive, and several of the participants already expressed interest in a similar Cycle 2 workshop. Tutorial material and presentations are available in electronic form on the conference website[3].

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References

Randall, S. & Testi, L. 2011, The Messenger, 144, 39

Links

[1] ALMA Science Portal: www.almascience.org
[2] More information on the ARC at: http://www.eso.org/sci/facilities/alma/arc.html
[3] Community Days 2012 website: http://www.eso.org/sci/meetings/2012/alma_es_2012/program.html

Figure 3. The workshop participants busy at the practical tutorial sessions.