Exploring the Cold Universe — A planetarium show for the IYA2009

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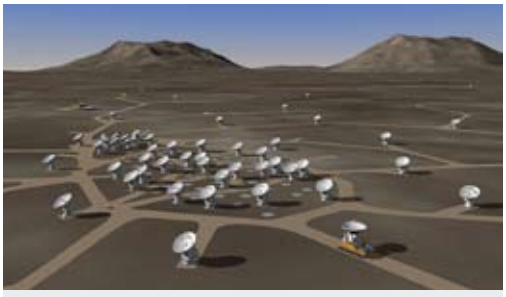
Abstract

ESO and the Association of French-speaking Planetariums are currently developing, in the framework of the International Year of Astronomy, a new planetarium show centred on the ALMA international astronomical project. The show, available in three formats and several languages, will allow the public to participate in a unique international project, whose main aim is to probe our cosmic origins by exploring the invisible part of the spectrum.

A new show

As part of a wide range of education and public outreach activities for the International Year of Astronomy 2009 (Pierce-Price et al., 2007), ESO[1], the European Organisation for Astronomical Research in the Southern Hemisphere, is presently collaborating with the Association of French-speaking Planetariums[2] (APLF) and other partners in Europe to produce a new planetarium show, of a duration of 30 minutes. This builds on the experience already gained by the APLF to produce unique planetarium shows at the European level. The APLF, born in 1984, but officially created in 1989, coordinates the operations of about 50 planetariums, totalling about 1,300,000 visitors per year in France. As member of the International Planetarium Society (IPS), the APLF has also established close links with planetariums from many other countries.

In 2001 the APLF produced, in collaboration with the French space agency CNES, a show about the Earth as seen from space, while in 2002, with ESO, it made a show for the 40th anniversary of ESO about the "Mysteries of the Southern Sky", celebrating the VLT's performance. Both shows featured in around 40 planetariums it in France, Germany, Belgium, Italy, Spain, etc. About 30 planetariums in several countries have already agreed to present the new show. The show will be available for



Credit: ESO

Figure 1 – ALMA will comprise initially 66 antennas to observe the sky in the millimetre and sub-millimetre wavelength domain.

[1] http://www.eso.org
[2] http://www.aplf-planetariums.org
[3] http://www.eso.org/public/astronomy/projects/alma.html

Credit: ESO

Figure 2 – The Chajnantor plain, at 5000 m altitude in the Chilean Atacama Desert, will host an array of 66 antennas.

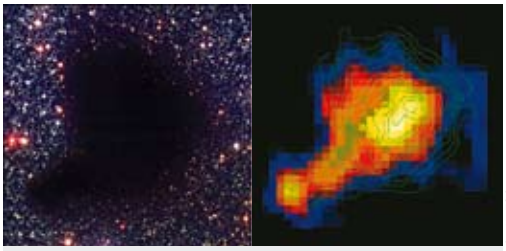
viewing from autumn 2008 — in order to be included in the school programmes — and officially inaugurated early 2009.

The ALMA project

ALMA[3] stands for Atacama Large Millimeter/submillimeter Array, and is without any doubt one of the largest ground-based astronomy projects of the next decade. It is presently being built on the 5000-m high plateau of Chajnantor in the Chilean Atacama Desert. This is higher than the highest summit in Europe, and yet astronomers are now building a fantastic facility to explore the Universe there! And not a small one. ALMA consists of two arrays. The first contains 50 antennas 12 m in diameter whose signals are combined electronically to achieve unprecedented resolution and sensitivity. The second, so-called Compact Array, consists of four 12 m and twelve 7 m antennas. The whole array is fully reconfigurable and the antennas can therefore be moved from a compact configuration where all the antennas are packed in a region about 150 metres in radius, to a very wide configuration, with antennas as far as 18 km from the centre of the array.

And in the same way that we need to combine many antennas to achieve the best results, ALMA can only exist because it is an international endeavour that covers four continents. ALMA is a partnership between East Asia — Japan and Taiwan, North America — the US and Canada, ESO for Europe, and Chile as the host country. The construction of ALMA started at the end of 2003 and has progressed very well since then. The first antennas arrived this year — five are already at the base camp — and the first science with a reduced array will begin in 2010, while the full array will be completed around 2012–13.

ALMA is not only a matter of scientific prowess; it is also a technological challenge. With the correlator at an altitude of 5000m, this is certainly the highest high-tech installation in the world. At such a high altitude there is only 50% of the oxygen available at sea level, which puts a heavy load not only on the people working there, but also on the material and equipment. Moreover, the conditions in this desert can be extreme, from very hot to freezing cold.



Credit: ESO

Figure 3 – Millimetric observations allow astronomers to probe the coolest objects in the Universe, where stars and planets form. A cloud of gas and dust is opaque to visible light (left), hiding its secrets, while with observations in the millimetre wavelength range, astronomers can see how stars form.

Credit: CNES/HST/ESO/APLF

Figure 4 (a-b) – APLF European productions in 2001 and 2002.

The 115-ton antennas need to be moved regularly, which calls for the use of transporters that have the equivalent of two Formula 1 engines and weigh 130 tons, but still can, with the help of a laser system, place the antennas with a precision of a few millimetres.

ALMA is working in the millimetre-submillimetre (mm/submm) wavelength domain, to probe the coolest objects in the Universe. Light at these wavelengths shines from vast cold clouds in interstellar space, at temperatures only a few tens of degrees above absolute zero, and from some of the earliest and most distant galaxies in the Universe. Astronomers can use it to study the chemical and physical conditions in molecular clouds — the dense regions of gas and dust where new stars are being born. Often, these regions of the Universe are dark and obscured in visible light, but they shine brightly in the millimetre and submillimetre part of the spectrum. ALMA will provide scientists with detailed images of stars and planets being born in gas clouds near our Solar System. It will also detect distant galaxies forming at the edge of the observable Universe, which we see as they were roughly ten billion years ago. ALMA will provide a window on celestial origins that encompasses both space and time, providing astronomers with a wealth of new scientific opportunities. Current mm/submm telescopes have already led to many discoveries — but compared to ALMA, these were only the tip of the iceberg. ALMA, with its incomparable power, both in terms of sensitivity and spatial resolution, will really open a new window on our cosmic origins.

A fruitful collaboration

The new planetarium show's emphasis is the incomparable scientific endeavour that the ALMA project represents and the technological challenges scientists are solving to address the quest for our cosmic origins. The show will be available at three different levels: fulldome video, AllSky immersive projection and video windows, and image projection and video window for the smaller planetariums. It will be available to all planetariums worldwide for a very small fee, depending on the type of planetarium, to cover basic costs.

ESO is responsible for the scientific data and the validation of the storyboard, providing visual elements such as images, computer simulations and videos, providing the associated documents, producing a Chilean version, and financially supports the project. The APLF is in charge of making the storyboard, producing the show in the three formats and five languages, and is responsible for the promotion, duplication and distribution in France and in Europe. We also have

an agreement with the German Planetarium of Augsburg to produce a German version, while others will most probably make Italian and Portuguese versions.

As far as the scientific content of the show is concerned, the emphasis will be on what ALMA will study, such as the analysis of distant galaxies and the study of the cold Universe, that is, the formation of stars and planets and looking back at our cosmic origins.

More specifically, the content describes how ALMA is an amazing instrument, doubling as a time machine, that allows astronomers to be a modern version of explorers seeking knowledge. The unique setting of ALMA in the Atacama Desert at an altitude of 5000 m is also emphasised, as well as the difficulty of building something in such a remote, inhospitable place. A rainbow analogy is made to explain the extent of the electromagnetic radiation, and the place of millimetre wavelengths between visible and radio waves. This is then linked to the use of ALMA to study the most distant galaxies — the first to have emerged from the Big Bang — as light is redshifted by huge amounts. Another analogy shows how millimetre radiation is an invisible form of light, extending its role to study clouds of gas and dust where stars and planets form but which are opaque to visible light.

In summary, ESO and the APLF strive to produce a spectacle of high quality, both technically and scientifically, in seven languages, that will not only be part of the IYA2009 programme, but will also be related to educational and outreach activities. Concerning education, the show will be associated to an ALMA Interdisciplinary Teaching Project ESO is currently developing, while the outreach activities are part of the ALMA EPO International Working Group's remit (Adams et al., 2007). All in all, it is our aim to have a spectacle that is attractive to everyone, from 7 to 77 years old.

References

- Adams M., Boffin H., Garnier W., Iono D. (2007), The Global ALMA EPO Programme: Communicating Astronomy with the Public at Millimetre and Submillimetre Wavelengths. This volume.
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