acterisation. We heard that the main purpose of the ELTs will not include the search for planets using astrometry, microlensing or photometric transit techniques (although follow-up using these methods is certainly envisaged). However, a lot is expected from radial velocity and direct imaging, and even the characterisation of their atmospheres is a goal.

Following the Tuesday afternoon social programme, which included a visit to the famous Porto wine cellars and a boat tour on the River Douro, the Wednesday sessions focused on the technical and astrophysical limitations to the detection of other planets using the radial velocity, photometric transit and astrometric techniques. Both the instrumental and astrophysical aspects are providing significant developments. Although stellar intrinsic phenomena and even the existence of multi-planet systems pose some difficulties to the detection of other Earths, a general consensus exists that it will be possible to detect Earth-type planets in the habitable zones of solar-type stars (spectral types G, K and M). Small M dwarfs may be particularly good targets for transit searches, but new generations of stable spectrographs will also allow the discovery of "exo-Earths" orbiting K and M dwarfs.

Most of Thursday was dedicated to discussion of the challenges and progress achieved towards the direct detection of Earth-like planets with ELTs. We learned that although it will be a difficult task, a number of promising extreme AO instruments are being planned that will allow direct images of planets orbiting other solar-type stars to be made.

Session 3: Exo-Earth characterisation

The final session began late on Thursday, opening the window on an impressive number of results showing how the direct detection and characterisation of exo-atmospheres is a fast-growing field. It is already possible to identify molecules in exoplanet atmospheres, to detect day and night temperature gradients, and to find evidence for atmospheric escape and variability. The advent of the ELTs will certainly open the way to new exciting science in this field, and may even allow the detection of biosignatures in the atmospheres of exo-Earths. The difficulty of modelling the atmospheres of exo-Earths was presented; however it was suggested that in this field observations will lead the theoretical findings.

Overall, the exceptional quality of the talks contributed to make this a great conference, where many different ideas were presented and discussed. We would thus like to deeply thank the scientific organising committee, the local organising committee and all the participants for making this a memorable event.

All the talks will be available (both in video and in pdf format) on the website[1] of the conference and a DVD will be sent to all the participants.

Links

[1] http://www.astro.up.pt/toe2009

Report on the ESO Workshop

Galaxy Clusters in the Early Universe

held at the Gran Hotel Pucón, Chile, 9–12 November 2009

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A workshop bringing together theoreticians and observational astronomers from different wavebands to discuss the current knowledge of galaxy clusters is briefly summarised.

Galaxy clusters are the most massive bound structures in the Universe. The most massive examples contain thousands of galaxies and are about a thousand times more massive than our own Milky Way. Since clusters can be detected from a time when the Universe was only a few billion years old all the way to present day, they serve as unique laboratories for studying environmental influences on galaxy formation and evolution. If we look back far enough we should be able to see clusters, and the galaxies within them, forming. Moreover, the number density of galaxy clusters is sensitive to cosmological parameters, such as the amount of matter in the Universe, the equation of state of the mysterious dark energy and the primordial power spectrum of density fluctuations.

For these reasons, the search for distant galaxy clusters is currently a very active field, with the number of known distant clusters or proto-clusters increasing rapidly. The detection of distant clusters of galaxies is challenging because methods that have traditionally worked well — such as the detection of the X-ray emission from the hot intracluster gas or optical imaging to detect clusters as enhancements in the projected galaxy

Participants at the workshop with the smoking Volcán Villarrica in the background.

distribution — become much less efficient as one goes to greater distances. Nevertheless, a variety of techniques, including optical, infrared and X-ray surveys, as well as surveys based on the Sunyaev-Zel'dovich effect, have identified a growing number of clusters in the early Universe. Alternative methods, such as the use of powerful radio galaxies and quasars as beacons for locating high-redshift clusters, are also providing promising new ways to identify and study the most distant galaxy clusters.

With this motivation, ESO organised a workshop in the resort town of Pucón in Southern Chile with the goal of bringing together theoreticians and observational astronomers working at different wavelengths to summarise the current state of knowledge of galaxy clusters.

The conference was held over four days in the Gran Hotel Pucón, which is situated on the shore of the beautiful Lake Villarrica. A fifth day was kept free for participants to explore the region and to participate in some of the adventurous activities that are on offer in this part of Chile. Quite a few of the participants climbed Volcán Villarrica, an active volcano that dominates the Pucón skyline. The volcano can be seen behind the participants in the conference photo.

About 100 participants attended the workshop. Over the four days of the conference, there were about 60 talks, of which eight were invited reviews, and twenty posters. The presentations covered a broad range of cluster studies, from the theorist's view of galaxy evolution in galaxy clusters to detailed observations of individual clusters. Particularly impressive to the authors of this report, were the size and quality of the multi-wavelength datasets that were presented during the workshop. These datasets represent the result of many years of dedicated work and many hours of telescope time. Also presented were a few record-breaking high-redshift clusters. We look forward to learning more about these clusters at one of the cluster conferences being held during 2010.

In view of the rapid progress that has been made in this field and the number of cluster conferences that will be held during 2010, the proceedings will only be made available from the conference website[1]. By the time this *Messenger* report appears, all the presentations and some of the first papers will be available.

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Links

[1] http://www.eso.org/sci/meetings/GCEU2009/

ALMA Achieves Closure Phase with Three Antennas on Chajnantor

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It is an exciting time for the Atacama Large Millimeter/submillimeter Array (ALMA). Following the shift of the focus of the testing activities from the ALMA Test Facility in Socorro, New Mexico (see *The Messenger*, 135, 61) to Chile at the end of 2008, the project has seen truly remarkable progress. Following conditional acceptance of the first antenna at the beginning of 2009, first fringes with two antennas were achieved at the Operations Support Facility (OSF at 2900 m altitude) after a few months (see *The Messenger*, 137, 17). Later in the year, three antennas were transported to the Array Operations Site (AOS, at 5000 m), where fringes were achieved with two antennas at submillimetre wavelengths. Finally, towards the end of the year three antennas were linked together and stable fringes and closure phase was achieved by the ALMA Assembly Integration and Verification (AIV) team (see ESO Press Release eso1001).

Following the successful checks on the three antenna interferometers and the deployment of the latest version of the ALMA software system, on 22 January 2010, the ALMA project has officially entered the Commissioning and Science Verification (CSV) phase. The goal for 2010 is to deliver the hardware, software