Report on the ESO-FONDAP Conference on

Globular Clusters – Guides to Galaxies

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Tom Richtler[1]
Søren S. Larsen[2]

[1] Universidad de Concepción, Chile
[2] University of Utrecht, the Netherlands

Background and venue

The role of ESO in the development of astronomy in Chile is difficult to overstate. However, the Chilean government is also well aware of the significance of science for the development of the country and has created large programmes for Chilean science to grow and maintain a scientific productivity competitive with that of countries with a longer scientific tradition. One of these programmes is called FONDAP (Fondo de Investigación Avanzado en Areas Prioritarias) and there is no question that astronomy is a priority field in Chile. The astronomy FONDAP programme (*www.cenastro.cl*) unites groups from Santiago (Universidad de Chile, Universidad Católica) and Concepción (Universidad de Concepción). One of the FONDAP goals is to support schools and conferences. Since globular clusters play an important role in the research of the Concepción group, we had the feeling that a small workshop of two or three days on globular cluster research would be due. But the reaction from the community was overwhelming and within a short time we had to drop the idea of an intimate workshop and instead had to face the challenge of a full-scale international conference, which would stretch our organisational and infrastructural capabilities to the limit. As so often, ESO was very generous and so a joint ESO-FONDAP conference on Globular Clusters in Concepción became reality.

The conference marked the five-year anniversary of the first-ever IAU symposium on Extragalactic Star Clusters (also the first IAU Symposium on Chilean soil) which was held 2001 in Pucón and was also co-organised by the Concepción group (Doug Geisler). In the intervening five years, an ESO workshop on the subject was organised in 2002 in Garching (Markus Kissler-Patig) and another meeting (primarily devoted to young star clusters) was held in Cancún, Mexico, in November 2003. Several other smaller workshops on star clusters have been organised since the Pucón meeting, and star clusters are often included in many other contexts (e.g. star formation, galaxy evolution), but it seemed very timely to meet once again in 2006 and discuss the vast amount of progress made.

The venue of the conference was the Lecture Hall of the Universidad de Concepción in the Facultad de Humanidades y Arte on the university campus. Many of the participants stayed at the Hotel Araucano in central Concepción, where also the welcome reception and conference dinner were held. With about 150 participants and many more requests for contributed talks than available slots, putting together the schedule was not an easy task. The final programme was busy with 23 review talks and 43 contributed talks, distributed over the five days (with Wednesday afternoon free). In addition, 58 posters were presented at the meeting. While the tight schedule unfortunately did not allow for a dedicated poster session, the posters were permanently mounted in the lobby adjacent to the lecture hall so that poster viewing was possible during every coffee break.

In the following, we describe in a general manner a few of the topics discussed, omitting all author names. The forthcoming proceedings will give the full credit to individual researchers.

Scientific topics

The selection of scientific topics discussed at the meeting already reflects much of the progress made over the past five years. The trend from previous meetings to view globular clusters (GCs) as members of an increasingly diverse 'zoo' of star clusters continued. At the high-mass end of the mass spectrum, several contributions discussed the objects now commonly referred to as 'Ultra Compact Dwarfs' (UCDs). It does not yet seem quite clear whether UCDs are a distinct class of objects, or if there is a gradual transition from high-mass GCs to UCDs and dwarf galaxy nuclei. Populations of relatively faint, extended star clusters which do not fit the classical description of globular clusters are now also being discovered in several galaxies, both in the halo of M31 and in the discs of lenticular galaxies. Young, massive star clusters (YMCs) in actively star-forming galaxies were discussed in several talks and the identification of these objects as young versions of globular clusters is becoming less controversial. Populations of intermediate-age (few gigayears) star clusters have now been identified in some merger remnants and may provide a crucial 'missing link' between the rich populations of YMCs observed in starbursts and mergers and the 'classical' old GCs. However, explaining the differences in the mass functions of young and old star clusters continues to be a field of active investigation. Increasing amounts of data are being collected for very young, still embedded star clusters, which may provide important clues to the star-formation process leading to GC/YMC formation. Such studies are likely to receive a tremendous boost once ALMA comes on-line.

Observational studies of extragalactic globular clusters are becoming more quantitative and detailed. Five years ago, little information was available about the age distributions of globular clusters beyond the Local Group. In the meantime, several spectroscopic and photometric studies have been published and tighter constraints are becoming available, although the measurements are demanding and the presence of intermediate-age GC populations in early-type galaxies is still debated. Even so, the distinction between 'old' and 'young' is still one between formation redshifts greater or less than 1.5–2, and it would clearly be desirable to push the limits further than that. Doing so for large samples of clusters may have to await future generations of extremely large telescopes. Constraints on alpha-to-Fe abundance ratios are becoming available from spectroscopy. An entirely new avenue of research is abundance analysis of extragalactic star clusters from high-dispersion spectroscopy, with some first results being presented at this meeting. In principle, this would already have been observationally possible five years ago with HIRES or UVES, but only now has the modelling of integrated GC spectra at high resolution reached a sufficiently mature level to allow a meaningful analysis. Other new results on old GCs

included the discovery of a colour-luminosity relation among the metal-poor globular clusters (the 'blue tilt'), and the possible presence of intergalactic globular clusters in some rich galaxy clusters. There was also a lively discussion of the colour bimodality in globular-cluster systems and its interpretation as a metallicity bimodality, a subject that has recently become quite controversial.

As in many other fields, large data sets are playing an increasingly important role for research in extragalactic globular clusters. One example is the ACS Virgo and Fornax surveys, which provide high-quality imaging of more than 100 early-type galaxies and their globular-cluster systems and were covered in several talks. This has allowed many results to be established with much greater significance than before. For example, correlations between the mean colours (metallicities) of globular cluster sub-populations and luminosities of their host galaxies are better revealed in these new data, and more accurate measurements of globular cluster sizes are possible with the better spatial resolution of ACS compared to earlier WFPC2 studies. Interesting links are also appearing between galaxy nuclei and supermassive black holes, whose masses follow very similar scaling relations with respect to the host-galaxy mass.

Dynamics of globular-cluster systems is another case where large data sets are playing an important role. Several hundreds to ideally 1000 or more radial velocities are needed in order to carry out a satisfactory modelling of the kinematic properties of GC systems. With such data sets, it becomes possible to put constraints on the detailed dark-matter distributions in galaxies, test alternative theories to dark matter (e.g. MOND), and determine the radial anisotropy of the velocity distributions, which has important implications for the dynamical evolution of GC systems. Such data sets are now becoming available, thanks to effective multi-object spectrographs on larger telescopes (GEMINI/GMOS, VLT/FORS2, FLAMES, VIMOS, Magellan/IMACS, Keck/DEIMOS, etc.).

Our own Galaxy and other galaxies in the Local Group will always be those that can be studied at the greatest level of detail and serve as comparison cases for more distant systems. Although the emphasis was on extragalactic GCs, a few talks covered classical topics in Galactic GCs (abundances, stellar-mass functions, CMDs) with less classical results. In particular, complementary information about the stellar populations in many Local Group galaxies is available by other means (e.g. from studies of field stars). Catalogues of globular clusters in M31 are still being improved and a large amount of photometric and kinematic information is now available for GCs there, which can be compared with other constraints on the accretion/merger history of M31 from studies of tidal streams. One controversial issue is the presence of intermediate-age globular clusters in M31, where adaptive optics imaging suggests that at least some objects previously identified as such may instead be loose groupings of stars ('asterisms') and not real GCs. Detailed studies of star clusters in M33 are more scarce, although it is now catching up with its larger cousins. In particular, M33 is interesting because of its relatively rich population of young populous star clusters.

While research in extragalactic star clusters remains dominated by a flurry of observational results, an increased interplay with theory is now forthcoming. Several talks covered aspects of galaxy formation and evolution in the cosmological context, and it is encouraging to see that cosmological simulations are starting to reach a resolution and sophistication including dissipational processes, where the formation of globular cluster-sized objects can be addressed. Different views about galaxy formation and the role of accretions, mergers and early collapse are now starting to converge, although the details are not yet clear. The spatial distributions of GC systems may even provide constraints on truly cosmological questions such as the epoch of reionisation. N-body simulations are now able to model star clusters with GC-like masses over cosmological timescales, resulting in a better theoretical understanding of the dynamical evolution of star clusters. However, the simulations are still having difficulties producing the observed, virtually universal mass function of old globular clusters as a result of evolution from an initial power-law distribution, except under special circumstances. The fractal structure of the interstellar medium might play an important role.

Final remarks

The lively response of the community attested to the fact that research in globular clusters is as active a field as ever. As noted by William Harris, a good indicator of the health of any field is its ability to attract new bright students, and there were many examples of this in Concepción. When will there be nothing left to work out for the next generation? Perhaps this will be when the actual cluster-formation processes and their dependences on physical parameters and environment are understood, when nucleation of galaxies is understood, when star formation is understood, when chemical enrichment is understood, in other words: not too soon. Globular clusters are involved in so many aspects of galaxy formation and evolution that they are really "Guides to Galaxies".

Our field seems well prepared to take advantage of the many new facilities that will become available in the next decade and beyond (ALMA, ELTs, JWST). We are therefore confident that there will be ample supply of new results for the next many more meetings to come.

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