

Fornax, Virgo, Coma et al.: Stellar Systems in High Density Environments

held at ESO Headquarters, Garching, Germany, 27 June – 1 July 2011

Magda Arnaboldi¹

¹ ESO

The workshop focused on recent observational progress in the understanding of stellar systems in the nearby clusters Fornax, Virgo, Coma et al. and provided a forum for comparing the results from theory and observations on galaxy evolution in high density environments at redshift zero.

Over the decade, the nearby galaxy clusters — Fornax, Virgo, Coma, Hydra and Centaurus, to name a few — have been the favourite targets of imaging and spectroscopic surveys like the Hubble Space Telescope Advanced Camera for Surveys (HST ACS), nearby cluster surveys (Virgo, Fornax and Coma surveys), the Next Generation Virgo cluster Survey (NGVS) at the Canada France Hawaii Telescope (CFHT), the SAURON and ATLAS-3D surveys of nearby galaxies and the 2dF Fornax cluster survey.

The strong scientific motivation for these extensive observational studies is driven by the presence of the oldest stellar populations and the products of the final collapse of massive stellar systems from star clusters with masses of $10^3 M_{\odot}$ to the brightest cluster galaxies with masses of $10^{13} M_{\odot}$. On account of their proximity, which ensures excellent intrinsic spatial resolution in comparison with more distant galaxy clusters and allows the observations of individual stellar sources that are not accessible further away, nearby clusters are excellent laboratories in which to study the physical properties of old stellar populations by resolving individual star clusters reaching down to single stars.

In addition to the study of the stellar component, by using several tracers for measuring the distances of the different galaxies in these clusters, it is possible to construct the volume distribution and set constraints on how and when the different components, dark matter and baryons, come together to form the structures that we now see. The various galaxy morphological types can also be



Figure 1. Photo of the participants at the workshop, taken in the grounds of ESO Headquarters in Garching during a coffee break on a sunny morning in June.

placed within the 3D structure of these clusters and information can be collected on the effect of high density environments on the morphology and evolution of individual galaxies. The measurements of the physical parameters of galaxies, on all mass scales and surface brightness levels, can then be compared with predictions from theoretical models for the evolution of galaxies and larger-scale structures. In this sense, the study of nearby clusters complements those focused on clusters at high redshift: it provides independent constraints which allow models for galaxies and structure evolution to be tested further.

There is an important tradition of workshops dedicated to nearby clusters at ESO, and more than 120 participants (see Figure 1) gathered at ESO Headquarters to join in the discussions. As it happened, the ESO workshop Fornax, Virgo, Coma et al. took place 27 years after the ESO workshop on the Virgo cluster in 1984 (Richter & Binggeli, 1985). Twenty-seven years ago, the Virgo cluster was labelled the “Rosetta stone” for many problems in extragalactic astronomy in the foreword section of the workshop proceedings. Clearly, the enthusiasm of the participants during the intensive sessions and the vibrant discussion

which took place at the end of the workshop indicate that the Virgo cluster and the other nearby clusters continue to fulfil the expectations formulated in 1984.

Workshop programme

Given the ambitious scientific programme, the sessions ran over five days of the week, including several exciting poster sessions, where the authors presented short two-minute talks on their work, 24 invited talks and 22 oral contributions. The poster announcing the workshop is shown in Figure 2. The complete programme of the workshop, including the presentations (in PDF format) is available¹, and is linked to the Astrophysics Data System (ADS).

The workshop started during the afternoon of Monday, 27 June, with a session dedicated to invited reviews on topics important as background for the properties of stellar systems in high density environments that were to be addressed during the following sessions. The five reviews presented the general observational properties of clusters, the morphology of clusters at high redshifts from high resolution numerical simulations, galaxies and their black holes, active galactic nuclei (AGN) feedback and the size evolution of massive galaxies. The next day was dedicated to an overview of the surveys of nearby clusters at different wavelengths, from X-ray, optical



Figure 2. The poster of the ESO workshop, Fornax, Virgo, Coma et al.: Stellar systems in high density environments. It illustrates the large-scale structures in the local Universe and examples of galaxies in a range of luminosities and sizes. This poster will appear as background in the Warner Brothers series *The Big Bang Theory*.

- What is the distribution of dwarf spheroidals and UDCs in nearby clusters?
- What produces low luminosity galaxies ($M_V > -16$) that are common to both groups and clusters? Are there enough low-luminosity irregulars to explain the many observed low-luminosity dwarf ellipticals?
- What is the relation between UCDs and bulges in compact dwarf galaxies?
- What are the most important scientific goals for future integral field unit spectroscopic surveys?

These questions represent a forward look in this area of research, which builds on 27 years of extragalactic studies in the nearby clusters since the ESO workshop on the Virgo cluster. Identifying these key questions sets an ideal bridge to the future as it highlights those exciting research areas that can be tackled by the European Extremely Large Telescope (E-ELT), as the high angular resolution and collecting power of an extremely large telescope are essential ingredients for the study of stellar populations at distances larger than 10 Mpc.

Again, the nearby clusters Fornax, Virgo, Coma et al. will be the first obvious targets for this new exciting era in extragalactic astronomy with many new amazing discoveries to be expected.

Acknowledgements

The LOC members Lodovico Coccato, Luca Cortese, Michael Hilker, Marina Rejkuba and Christina Stoffer are acknowledged for their hard work and support. The support by ESO students, and by Fei Zhao in particular, during question time is gratefully acknowledged. The intense and stimulating scientific programme of the workshop was defined by the SOC whose members were: Magda Arnaboldi, Noubuo Arimoto, Michele Cappellari, Eric Emsellem, Bill Harris, Ken Freeman, John Kormendy, Harald Kuntschner, Ortwin Gerhard, Claudia Maraston, Lucio Mayer, Simona Mei, Bianca Poggianti, Sadanori Okamura, Tom Richtler.

References

Richtler, O.-G. & Binggeli, B. (eds) 1985, ESO Workshop on the Virgo Cluster of Galaxies

Links

¹ Conference presentations available at: http://www.eso.org/sci/meetings/2011/fornax_virgo2011/programme_final.html

and near-infrared, to millimetre and radio wavelengths. On Wednesday the workshop started with a session dedicated to the faint end of the galaxy luminosity function with presentations on the physical properties of globular clusters, ultra-compact dwarfs (UCDs), and dwarf galaxies. It then moved on from photometry to kinematics and from the faint to the bright end of the galaxy luminosity function. Several topics were covered in this session: the inner and outer halo dynamics of early-type galaxies; the role played by merger events in shaping both light and kinematics in these objects; and the mass determination in massive galaxies using X-rays.

On the following day, the topics of the morning session covered the bright end of the luminosity function of galaxies in the nearby clusters and their physical properties. In the afternoon session, the subject shifted to the studies of the intra-cluster light (ICL), with presentations of results coming from both observations and numerical simulations. On the last day of the workshop, the morning session was dedicated to the discussion of the gas properties of galaxies with emphasis on the ram pressure stripping of gas experienced by galaxies as they

fall into the potential well and through the hot diffuse X-ray halo in the nearby clusters. Finally the workshop ended with a lively discussion chaired by Ortwin Gerhard and Roger Davies.

The discussion was structured around several questions which came about during the working sessions. These questions covered nearly all the topics presented at the workshop and are listed below:

- Is the current observational understanding of how the most massive galaxies form reconciled with the hierarchical formation paradigm? Are the observed distributions of angular momentum, colour gradients, alpha-element-to-iron ratio (α/Fe) and galaxy sizes compatible with these predictions?
- Where does the high metallicity in the hot coronae in clusters come from?
- Are S0 galaxies stripped or starved spirals?
- Does harassment cause significant star formation in gas driven to the centre of galaxies?
- How important is the star formation outside galaxies as seen in H α filaments and stripped gas?
- How do we learn from the ICL about galaxy evolution?