The 2nd ESO/CERN Symposium on

Cosmology, Astronomy and Fundamental Physics

will be held at ESO, Garching bei München (F. R. G.), from 17 to 21 March, 1986

The preliminary programme includes the following topics and speakers:

Neutrino Properties (K. WINTER, CERN, Geneva).
Extragalactic Distance Scale (To be announced).
Cosmic Background Radiation: Observations (F. MELCHIORRI, University of Rome).
The Cosmic Background Radiation and the Formation of Structures (R. A. SUNYAEV*, Space Research Institute, Moscow).
Experimental Status and Prospects of Particle Physics (C. RUBBIA, CERN, Geneva/Harvard University, Cambridge, MA).
Prospects for Future High-Energy Accelerators (S. VAN DER MEER, CERN, Geneva).
High Energy Gamma Ray Sources (To be announced).
Acceleration of High Energy Particles (C. CESARSKY, Observatoire de Meudon, Paris).
Superstrings and Their Cosmological Implications (M. B. GREEN, Queen Mary College, London).
Superdense Matter: Cosmological Aspects (D. N. SCHRAMM, University of Chicago).
Superdense Matter: Laboratory Aspects (K. KAJANTIE, University of Helsinki).
Inflationary Scenarios for the Early Universe (To be announced).
The Age of the Observable Universe in the Inflationary Cosmology (W. A. FOWLER, Caltech, Pasadena).
Distribution of Galaxies and Their Clustering Properties (G. EFSTATHIOU, University of Cambridge).
Particle Dark Matter (J. PRIMACK, University of California, Santa Cruz).
Astrophysical Dark Matter (M. J. REES, University of Cambridge).
Singularities in General Relativity: Possible Astronomical Implications (S. CHANDRASEKHAR, University of Chicago).
Concluding Lecture (D. W. SCIAMA, Oxford University/ISAS, Trieste).

* Participation has not yet been confirmed.

The aim of the symposium is to establish the status of our knowledge on the subject and to provide a forum for discussions among people from different disciplines. To this end about equal time will be dedicated to the formal lectures and to the general discussions on each topic. The audience will be mainly composed of about equal numbers of astrophysicists and particle physicists and will be limited to approximately 150 participants.

The participation in the symposium is by invitation only. People who are definitely interested in participating in the symposium should write to the chairmen of the Scientific Organizing Committee at the addresses below prior to 30 November 1985.

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Globular Clusters in NGC 3109: Probes for the Study of Galaxy Evolution

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Any observer at La Silla who is not working in a telescope control room or watching a movie during a stormy night has the opportunity to see one of the most splendid wonders in the sky without any telescope: Omega Centauri, seemingly a patchy star, but in fact the brightest globular cluster of our Galaxy. Such massive subsystems of a galaxy, each with a

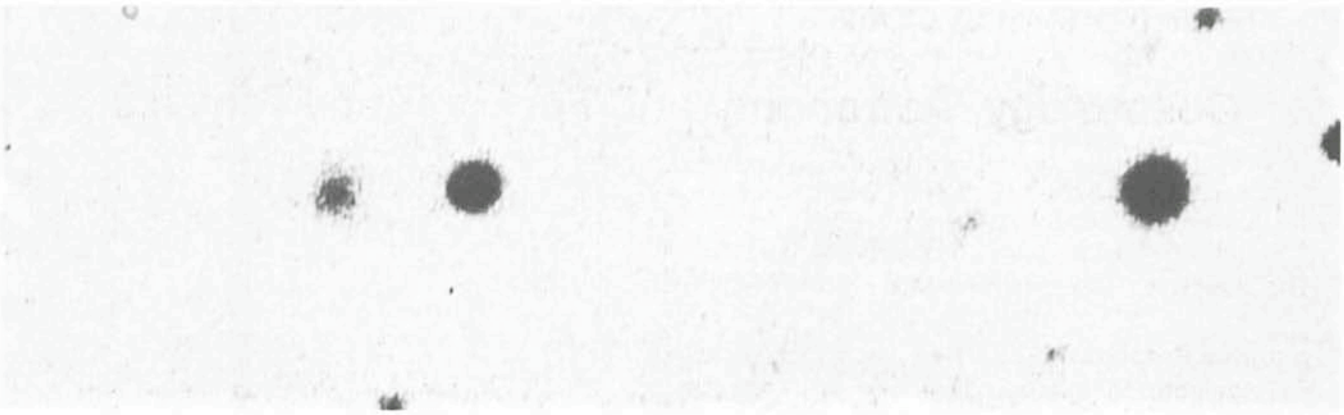

Figure 1: *A two-minute exposure of a globular cluster candidate in NGC 3109, obtained with the CCD camera at the ESO 2.2 m telescope in the V passband. Note the contrast between the fuzzy appearance of this object on the left with the neighbouring star image to its right.*

content of up to a million stars are quite frequent in the universe. We know many thousands of them, most of them around the giant elliptical galaxies of the Virgo cluster of galaxies.

Some Problems

Our own Galaxy possesses at least the 150 globular clusters which were detected up to the present (including doubtful or far outlying objects). From their integrated spectral features it is well known that globular clusters in elliptical or tightly wound spiral galaxies are among the oldest stellar systems we know. In contrast, loosely wound spiral and irregular galaxies like the Magellanic Clouds, contain frequently also luminous and populous star clusters of very young age, but with the typical geometrical structure of the "normal" old globular clusters. Obviously, there is a correlation between the structure of a galaxy and its ability to form globular clusters. Surprisingly, there is no correlation between the mass of a parent galaxy and its content of globular clusters. For example, twice as many globular clusters are known in the tiny Fornax dwarf galaxy as in the ten thousand times more massive giant radio galaxy Centaurus A. Another puzzle may be the location of globular clusters within a galaxy. In galaxies with marked disks the globular clusters are found in a spherical halo around the center of the galaxy. But although there is a clear density gradient with respect to the center, individual clusters with very large mass are observed at large distances from the apparent outer limits of the galaxy. For example the cluster NGC 2419 of our own Galaxy, a quite massive object, has twice the distance from the center of the Galaxy than the Large Magellanic Cloud. Also in the Andromeda galaxy M 31 the brightest known globular cluster has the largest angular distance, far from the region where similar massive stellar aggregates of young objects are found. This is the point to ask (F. Zwicky did that already 30 years ago!) if there are genuine intergalactic globular clusters, and if there is a difference in the internal structure of globular clusters and dwarf galaxies. Dwarf elliptical systems are usually found as companions of giant galaxies and appear tidally stripped in a similar way as the globular clusters. The main difference among them seems to be the surface brightness which is higher for a globular cluster of a given mass by a factor of roughly 100. The only known exception is M32, a companion of the Andromeda galaxy.

These are some of the problems (implicitly connected with those of galaxy evolution) which make the study of galactic and extragalactic systems of globular clusters so interesting. A very important physical parameter for the description of the distribution and interaction of the stellar content of a galaxy bound in globular clusters with the non-cluster content is the angular momentum and its distribution. Typically, a considerable part of the rotational angular momentum of a galaxy is stored in the orbits of the globular clusters. Quite rewarding targets for the study of phenomena related to the complex problem of the formation and evolution of globular clusters and their parent galaxies themselves are dwarf galaxies, because the physical conditions are simpler than in giant galaxies. Some of the evolutionary processes seem to take place on a slower time scale because of the weaker gravitational potential.

The Targets

We started a program of observations of globular cluster systems in nearby dwarf galaxies and selected objects for which no observations for the existence of globular clusters have been carried out. Our main targets were IC 10, a northern irregular object, which just grazes the horizon of La Silla (we observed it from Calar Alto in Spain), and the more southerly placed object NGC 3109, a quite large but to our surprise observationally fairly neglected galaxy of the Magellanic type. This galaxy seems to be just outside the Local Group of galaxies and we see it nearly edge-on. In the first step of our study we searched the available sky surveys for images with condensed but non-stellar appearance in the vicinity of NGC 3109. About half a dozen globular cluster candidates could be isolated. Their images resemble closely those of the major globular clusters of the Andromeda nebula, but smaller in size and integrated brightness on account of the larger distance of NGC 3109. At the end of June 1984 we had the possibility to verify these detections by CCD camera observations with the 2.2 m telescope on La Silla. Although the season for observations of NGC 3109 was quite late and one of the two available nights was cloudy, a few short and a long exposure of two target objects in NGC 3109 could be obtained. The short exposures show them as patches with a smooth intensity profile of round shape (Fig. 1), and the long exposure images appear only slightly more extended. Also the outermost parts of the latter images are not resolved into stars, but their patchy appearance resembles the statistical distribution of stars which is typical for globular clusters as can be seen on photographs e.g. of the bright galactic globular cluster M5. Though there are morphological differences between giant elliptical galaxies and globular clusters, it cannot be excluded that an apparent globular cluster of a nearby galaxy is confused with a distant background elliptical galaxy. The easiest way of distinction would be the measurement of the radial velocities of the relevant target objects. However, the nature of the found objects is much better established, and they are quite probably genuine globular clusters of NGC 3109: Their colours are moderately red, and we think they are normal halo objects of this galaxy. This is supported by their distant position from the main disk of NGC 3109.

Unfortunately the other cluster candidates of NGC 3109 could not be observed during this observing run. But the remainder of the observing time was used to observe some other nearby galaxies. A very interesting galaxy turned out to be the probably outlying member of the Sculptor group of galaxies A0142-43. In its halo two objects were observed which resemble those of the found globulars in NGC 3109, and may be even a bit larger in their absolute dimensions. Again, their position relative to the parent galaxy and their colours indicate typical halo objects. A huge H II region in the main body of A0142-43 shows that star-forming processes took place quite recently in it.

If there are populous clusters of very young age associated with it they are veiled by this bright gas complex. It should be noted that the estimated absolute luminosity of A0142-43 is 1.5 magnitudes fainter than that of the Small Magellanic Cloud.

We can conclude that our observations tend to confirm the complex situation among the galaxies and their cluster systems. Although it may be useful to detect new cluster systems, the relevant information of their role among the evolution of galaxies can certainly much better be found in detailed kinematical studies.

Chromospheric Modelling in Late-type Dwarfs 2. CES Observations of Active and Quiescent Stars

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1. Introduction

For many years it has been accepted that a stellar atmosphere cannot be considered as a closed thermodynamic system isolated by notional adiabatic walls, and without exchange of matter with the surrounding interstellar medium. A detailed exchange of ideas, developed earlier by Pecker, Praderie and Thomas (1973, *Astron. and Astrophys.*, **29**, 283) can be found in Thomas' monograph "Stellar Atmospheric Structural Patterns" (1983, NASA SP – 471).

Twenty years of UV observations from space have given us clear evidence that stars in every part of the HR diagram are losing mass, and that their external layers are heated by non-radiative energy fluxes up to coronal temperatures of several millions of Kelvins. These major departures from conditions of equilibrium make the modelling of a stellar atmosphere a more difficult task. In fact, the computation of detailed models for the solar and stellar atmospheres is even more difficult than the corresponding problem for photospheres. As discussed in the first article (*The Messenger,* **38,** p. 24), chromospheric models must take into account not only the severe departures from LTE and radiative equilibrium, but also the increased importance of magnetic fields in controlling the energy transport, as well as the linked horizontal inhomogeneities in density and temperature. The most valuable observations available for constraining model chromospheres are high resolution spectra of the lines of the most abundant elements, especially Hα, the H and K lines of Ca II, the infrared triplet of Ca II, and the h and k lines of Mg II.

In this paper we shall describe the observations that we have obtained for a sample of active and quiescent late-type dwarfs as an input for chromospheric modelling. We describe briefly the background of the program originating in IUE observations of Mg II lines, and the objectives of our complementary observations of chromospheric lines at ESO. From the spectra obtained with the Coudé Echelle Spectrograph (CES) we have derived preliminary spectroscopic indicators of activity. We show how this empirical approach can provide a guideline for the next phase of our program: quantitative line modelling from which should emerge the temperature structure, the energy balance, and the structure of the heterogeneity of late-type chromospheres.

2. IUE Observations of MgII Lines, and the Background to the Program

During the past six years we have been observing a representative sequence of late-type (late F and G) dwarfs using the high resolution spectrograph of IUE to obtain high quality profiles of the h and k lines. As described in article I, an almost serendipitous consequence of the failure of the stars to show reasonable variability has been a set of averaged profiles of very high quality, with spectral resolution of 1.8×10^4, high enough to resolve the Doppler self-absorbed parts of the core, and signal to noise ratio of 30 even in the hl and kl minima, good enough for model fitting. Thanks to the powerful IUEARM set of data reduction programs we have been able to identify and remove the interstellar Mg II, leaving line shapes which reflect intrinsic chromospheric and photospheric processes. In addition, absolute fluxes in Mg II have been obtained for comparison with theoretical predictions.

These predictions are of two types. One concerns the way in which energy is deposited within the chromosphere: whether by acoustic or magneto-acoustic input. This we can examine through a comparison of line profiles with model atmospheres. The second is the relation between age, rotation rate and chromospheric activity, first quantified by Wilson (*Ap. J.*, 1980: **226,** 379) and subsequently explored observationally by Vaughan and his co-workers. Activity indicators can be derived from spectra, calibrated in a coherent manner, and studied for variations in effective temperature, rotation rate and age. In a second step the line profiles can be modelled in detail. An intrinsic weakness of any chromospheric model based on