COMMISSION No. 37

STAR CLUSTERS AND ASSOCIATIONS

(AMAS STELLAIRES ET ASSOCIATIONS)

PRESIDENT: D.C. Heggie

In addition to the Commission sessions described below, the Commission also participated in the following:

1. Joint Discussion II: Formation and Evolution of Stars in Binary Systems (organiser: R.C. Smith)
2. Joint Commission Meeting 5: Spectroscopy of Individual Stars in Globular Clusters and the Early Chemical Evolution of the Galaxy (organiser: G. Cayrel de Strobel)
3. Joint Commission Meeting 6: Stellar Photometry with Modern Array Detectors (organiser: F. Rufener)
4. Session 37/4 = 26/6 = 42/2: Formation of Close and Wide Binaries (organiser: V.L. Trimble)
5. Session 37/5 = 30/4: Progress in the Understanding of the Dynamics of Star Clusters (organiser: C. Pryor)

Reports of the Joint Discussion and of JCM 6 will be found in *Highlights of Astronomy*. It is intended that the proceedings of JCM 5 will appear in due course as a publication of the Paris Observatory. Reports on sessions 37/4 and 37/5 will be found in this volume under the reports of Commissions 42 and 30, respectively.

5 August 1988

BUSINESS SESSION SECRETARY: A.G.D. Philip

1. Scientific Organising Committee, 1988-91

It was agreed to propose the following:

G.L.H. Harris (President)
C. Pilachowski (Vice-President)
D.C. Heggie (Past President)
J.E. Hesser
J-C. Mermilliod
R.R. Shobbrook
J.L. Zhao
K.A. Janes

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D.A. Vandenberg
J. Claria

2. Commission membership

The President gave the names of 22 IAU members, and 14 proposed members of the IAU, who had applied to join Commission 37. There had been one resignation, and one non-member of the Union was continuing as a consultant of the Commission. These changes, which were approved by the meeting, bring the membership of the Commission to 201.

3. Stars in open clusters

J.-C. Mermilliod described the development of his database on observational data for stars in open clusters, and recommended that future observations should be better coordinated, in order to identify the clusters and the kinds of data where improvements would be most useful. There was much discussion on these issues, which extended also to globular clusters and to associations, and on the future structure of the Commission Triennial Report. In conclusion it was agreed to set up a Working Group on the Acquisition and Compilation of Data on Clusters and Associations, with the following members : J.-C. Mermilliod (Convener), K. Janes, C. Pilachowski, J.E. Hesser, R.D. Mathieu, R.E. White, J.-L. Heudier, G. Lyngå and G.L.H. Harris. A suggestion that a review paper should be written, to summarise the issues involved, was also approved.

4. Atlas of cluster photographs

Good progress on this project, which had been set in motion at the 18th General Assembly, was reported by J.-C. Mermilliod and J.-L. Heudier. The greatest remaining need is for large scale plates of the smallest clusters.

5. Other Business

G.L.H. Harris reported on suggestions, received from Commission members, on a system of nomenclature for clusters in extragalactic cluster systems. Discussion concentrated on the possibility of names based on radial coordinates relative to the centre of the parent galaxy. C. Pilachowski reported on relevant items from Joint Discussion I (Documentation, Data Services and Astronomers), especially archiving of observational data.

5 and 6 August 1988

SCIENTIFIC SESSION: POSTER SESSION

SECRETARY: D.C. Heggie

The following papers were displayed, and a discussion session, chaired by K.C. Freeman, was held in the afternoon of 5 August.

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K. Akiyama & D. Sugimoto: Evolution of self-gravitating many-body system with rotation.

E.J. Alfaro & J. Cabrera-Cano: NGC 752 revisited - membership study from Ladovski's proper motion study.

H.C. Bhatt & R. Sagar: Distances to open star clusters - the kinematical method.

E. Brocato, R. Buonanno, V. Castellani & A. Walker: LMC cluster NGC 1866: a new investigation.

I.R. Brodie, R.D. Cannon, R.J. Dickens, W.K. Griffiths & R.G. Noble: Cluster membership determination of stars at the MS turnoff of ω Centauri.

J. Cabrera-Cano & E.J. Alfaro: A non-parametric approach to the membership problem in open clusters.

C.S. Chiosi, A. Bertelli, G. Meylan & S. Ortolani: Globular clusters in the LMC: NGC 1866, a test for convective overshoot.

C.A. Christian, J.N. Heasley, E.D. Friel & K.A. Janes: The giant branch of Mayall II: a globular cluster in M31.

M.S. Chun: Radial colour gradient in 47 Tuc.

A. Dapergolas, E. Kontizas, F. Pasiani, M. Pucillo & P. Santin: An age estimate for the NGC 456, 460 and 465 SMC constellation.

A.J. Delgado & E.J. Alfaro: On the calibration of intrinsic colours in *uvby* photometry

A.J. Delgado, E.J. Alfaro & A. Aparicio: CCD differential photometry of stars in the young open cluster NGC 7128. Preliminary results.

R.J. Dickens, I.R. Brodie, E.A. Bingham & S.P. Caldwell: A catalogue of magnitudes and colours in the globular cluster omega Centauri.

T. Lloyd Evans & L.G. Underhill: Correlated abundance variations in ω Centauri.

E.M. Green, M.S. Bessell, P.Demarque & C.R. King: An age spread among galactic globular clusters using the revised Yale isochrones and a new semi-empirical UBVRI calibration.

W.E. Harris, J.W. Allwright, C.J. Pritchet & S. van den Bergh: Globular Cluster Systems in Virgo: New observations from CFHT.

D.C. Heggie, J.Goodman & P. Hut: On the exponential divergence of N-body systems.

E. Kontizas, M. Kontizas & M. Metaxa: Small faint clusters in the LMC.

E. Kontizas, M. Kontizas, G. Sedmak & R. Smareglia: Ellipticities at R_h of the LMC star clusters.

E. Kontizas, M. Kontizas & E. Xiradaki: The stellar content of binary star clusters in the LMC.

P. Mazzei & L. Pigatto: The Pleiades age and the sequential star formation.

J.-C. Mermilliod: BDA - a database for stars in open clusters.

M. Metaxa, M. Kontizas, E. Kontizas: 8 star clusters of the LMC periphery with evidence of halo region.

J.L. Zhao: Current and future studies of open clusters at Shanghai Observatory.

At the poster discussion session two issues in particular received much attention: (i) problems of the determination of cluster ages by model isochrone fitting, and (ii) the complexities of abundances in stars in globular clusters.

6 August 1988

SCIENTIFIC SESSION: THE ABUNDANCE SPREAD WITHIN GLOBULAR CLUSTERS

CHAIRMAN: T. Lloyd Evans

The following papers were presented:

N. Suntzeff: The metal-poor clusters.

G.H. Smith: The metal-rich clusters.

R.J. Dickens: ω Centauri.

C.A. Pilachowski: High resolution spectroscopy - quantitative results and critical tests.

A.V. Sweigart: Theoretical considerations.

These presentations were followed by a panel discussion involving R.A. Bell, K.C. Freeman, R. Gratton, J.E. Hesser, and R.P. Kraft. It is intended that the invited review papers will be included in a publication of the Paris observatory.

9 August 1988

SCIENTIFIC SESSION: STAR CLUSTERS IN THE MAGELLANIC CLOUDS (JCM7)

CHAIRMAN: P. Demarque

There were three main speakers:

G. Meylan: Structure and Dynamics

Abstract. Because of lack of good observations, the structure and dynamics of the Magellanic clouds' star clusters are still largely unknown. The fact that globular clusters of all ages exist in the clouds gives a unique opportunity to check the theoretical prediction concerning a relation between age and ellipticity (the youngest clusters being the flattest). Surface brightness profiles (from surface photometry and star counts) and velocity dispersions (from integrated light spectra and individual stars) will allow a systematic use of King-Michie models to establish reliable comparison with clusters in the Galaxy. Collapsed clusters exist in the LMC (two such clusters have been observed near the bar) and surveys undertaken will soon give a general census.

P.R. Wood: Advanced Stages of Stellar Evolution in Magellanic Cloud Clusters

Abstract. The flurry of activity involving the discovery, infrared photometry, and low-dispersion spectroscopy of AGB stars in intermediate age clusters in the Magellanic Clouds has now slowed down after providing a major set of constraints which theoretical models must satisfy. The generally predicted evolutionary sequence in spectral type up the AGB from M-S-C has been verified (Lloyd Evans 1984, MNRAS, **208**, 447). The luminosity at which this transition M-S-C occurs can be derived as a function of cluster age/turnoff mass using the infrared data and the growing number of accurate cluster ages now in the literature

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(see compilation in Mould and Da Costa 1987, CTIO 25th Anniversary Symposium). The theoreticians are struggling with limited success to produce carbon stars at the observed luminosities (Lattanzio 1988, in IAU Colloquium 106, *Evolution of Peculiar Red Giants*). Another parameter that has been determined as a function of cluster age/turnoff mass is the luminosity at the AGB tip (Mould and Aaronson 1986, Ap.J., **303**, 10). The limit luminosity is determined by mass loss, probably of two separate kinds. Note that the tip luminosity is well above the luminosity for onset of shell flashes (Lattanzio 1988). At luminosities below $M_{bol} \sim -6$, a strong stellar wind ('superwind') of the type operating typically around OH/IR stars and dust-enshrouded carbon stars should operate; a Reimers-type mass loss law seems to (qualitatively) predict the AGB tip luminosity in this case (Mould and Aaronson 1986). However, recent derivations of mass loss rates indicate that real red giant stars do not follow the Reimers mass loss law (Wood 1987, in *Stellar Pulsation*, eds. A.N. Cox *et al*) so that any agreement between the observed tip luminosities and those derived from a Reimers mass loss law must be considered fortuitious. A second mechanism, radiation pressure ejection, may come into play in stars more luminous than $M_{bol} \sim -6$ (Wood and Faulkner 1986, Ap.J., **307**, 659). AGB stars more luminous than $M_{bol} \sim -6$ do exist on the AGB (Hughes and Wood 1987, Proc. Astr. Soc. Australia, **7**, 147); these stars are probably the most massive AGB stars.

The pre-AGB evolutionary phases of stars in Magellanic Cloud Clusters have also been receiving recent attention. Searches for variable stars are yielding new candidates (new Cepheids in NGC1866 have been identified by Storm *et al* 1988, Astr. Ap., **190**, L18). Constraints on the distance moduli to the SMC and LMC have been derived by Seidel, Da Costa and Demarque 1987, Ap.J., **313**, 192 from clump star luminosities in intermediate age clusters. An area of greatly increasing activity is the determination of accurate HR diagrams for Magellanic Cloud clusters. From the stellar evolution point of view, these results will be invaluable in determining the extent of overshoot during the main sequence phase of evolution. The data and analyses obtained so far are contradictory: for example, compare Chiosi and Pigatto 1986, Ap.J., **308**, 1 and Mateo and Hodge 1987, Ap.J., **320**, 626; and Brocato, Buonanno, Castellani and Walker 1988 (preprint) and Chiosi, Bertelli, Meylan and Ortolani (preprint). Determination of accurate HR diagrams for Magellanic Cloud clusters with ground-based CCDs and with the HST will be an active area of research over the next few years.

G.S. DaCosta: The Clusters as Signposts for the Chemical Evolution of the Magellanic Clouds

Abstract. Based on a compilation of the most recently available data for the star clusters of the Magellanic Clouds, the relation between age and abundance in the Large and Small Magellanic Clouds has been investigated. In the LMC, there is a distinct lack of well studied clusters with ages between 3 billion years and the age, taken as 15 billion years, of the small number of cluster analogues to the galactic halo globular clusters. The lack of clusters in this age range is ascribed to a combination of the effect of fading as clusters age, which encourages the selection of younger clusters in magnitude limited surveys, and the disruption of clusters, for which Hodge has recently determined a timescale of the order of 1 billion years. The lack of clusters between 3 and 15 Gyrs means the age-abundance relation for the LMC is only loosely constrained by the star clusters: the mean abundance appears to have risen slowly from [Fe/H] $\simeq -0.6$ at 2 Gyrs to its present value of [Fe/H]

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$\simeq -0.3$ dex. Prior to 2 Gyrs, the abundance must have risen from approximately [Fe/H] $= -2.0$ dex, the mean abundance of the oldest clusters, but there is little information on the rate of this enrichment.

In contrast to the LMC, the SMC does contain bright clusters in the 3 - 12 Gyr age interval, with Kron 3 being the archetypal example. On the other hand, and again in contrast to the LMC, there are no clusters in the SMC that are as old as the Galactic halo globular clusters. Using these clusters as a guide, it appears that the abundance of the SMC rose slowly but steadily to [Fe/H] $\simeq -0.7$ dex at an age of approximately 1 Gyr. Since that epoch, the abundance has remained essentially constant.

A comparison has also been made between the ages and abundances determined from integrated techniques, both spectroscopic and photometric, and those inferred from direct c-m diagram studies. It is concluded that while most photometric techniques have good age sensitivity up to ages of approximately 2 - 3 Gyr, they fail to discriminate between clusters of older age. Age discrimination for these older clusters can be achieved with spectroscopic data using the hydrogen-line strength versus metal-line strength diagram; better sensitivity occurs for high S/N and higher resolution observations. Ultimately, when additional clusters have been observed spectroscopically, it should be possible to provide an accurately calibrated version of this diagram that can be used to study the clusters of other galaxies to which only integrated techniques can be applied.

In addition a number of shorter contributions were included:

S.M. Fall, R.A.W. Elson and K.C. Freeman: The Internal Structure and Kinematics of Rich Young Star Clusters in the Large Magellanic Cloud

Abstract. We have determined the surface brightness profiles of ten young star clusters in the LMC, using aperture photometry and star counts. The ages of the clusters range from 8 million years to 300 million years. The profiles extend over 8-10 mag in surface brightness and to radii of about 4 arcmin, much farther than in previous studies. Most of the clusters in our sample do not appear to be tidally limited. At large radii the projected density falls off as $r^{-\gamma}$ with $2.2 < \gamma < 3.2$, and the median value of γ equals 2.6. With one possible exception, we find no evidence for mass segregation.

In a second study, we have measured the velocities of individual stars within three of the young LMC clusters. The internal velocity dispersions are small, about 1km/s, requiring accurate determinations of the observational errors. From the surface brightness profiles and the velocity dispersions, we estimate the masses and mass-to-light ratios of the clusters. With these results and our estimates of the gravitational field of the LMC, we can determine whether the clusters are in fact tidally limited. It appears that they are not. This confirms our previous suggestion, which was based on the surface brightness profiles and stellar population models to estimate the masses. We find that up to 50% of the masses in the clusters currently extends beyond eventual tidal radii as unbound halos. The most likely explanation is that the clusters or protoclusters lost much of their mass, either in the form of stellar ejecta or in gas that was expelled during star formation.

P. Linde, G. Lyngå and B. Westerlund: A Comparison of the LMC Clusters LW 55 and HS 96

Abstract. The aim of a project now under way at the Lund and Uppsala Observatories is to compare open clusters and field stars in two regions on either side of the bar in the LMC. The discussion of the clusters in these regions aims at relating the star formation history of the areas to the present stellar content of the open clusters. As a first step we now present a photometry of the two clusters LW 55 and HS 96. Their ages and luminosity functions will be compared and discussed.

Finally, *M. Kontizas* described recent work on several issues: mass segregation, binary clusters, extended cluster halos, and cluster ellipticity; *J.-C. Mermilliod* discussed field-star contamination in simulated clusters in the Clouds; *B. Baschek* outlined work at Heidelberg on near-main sequence B stars in cloud clusters; and *C. Chiosi* discussed integrated properties of the clusters, especially the bimodal distribution of B-V.

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