

## COMMISSION NO. 37

### STAR CLUSTERS AND ASSOCIATIONS (AMAS STELLAIRES ET ASSOCIATIONS)

PRESIDENT: G.L.H.HARRIS

SECRETARY: C. PILACHOWSKI

#### BUSINESS SESSION

##### I. IAU REPORT ON ASTRONOMY, COLLOQUIA ETC.

The Business Meeting of Commission 37 was called to order by Acting President and Vice President C. Pilachowski. She conveyed the regrets of President G. Harris at being unable to attend the General Assembly. Other members of the Organizing Committee present included J. Hesser and J. Zhao.

##### II. MEMBERSHIP:

Commission 37 approved and welcomed new members proposed by the various national committees, as well as several IAU members who requested to join the commission. These included Eugene Milone of Canada, David Latham of the US, M. Tsvetkov of Bulgaria, Georges Meylan of the US, and Mariano Mendez of Argentina.

##### III. OFFICERS:

The new President of Commission 37 is Jean-Claude Mermillod of Switzerland. Alejandro Feinstein of Argentina is the new Vice President. The members of the Organizing Committee for the triennium 1991-4 are Past President G. Harris of Canada, K. Janes of the U.S., D. Vandenberg of Canada, J. Claria of Argentina, J. Zhao of the P.R.C., R. Buonanno of Italy, G. Da Costa of Australia, and G. Meylan of the U.S.

#### SCIENTIFIC SESSIONS

The first scientific session of Commission 37 was held on Monday, 29 July 1991, on the subject of Binary Stars, Radial Velocities, and Open Cluster Memberships. The double session was chaired by C. Pilachowski and J. Hesser, and the following 7 invited talks were presented:

##### 1 "ECLIPSING BINARY STARS AS A DIAGNOSTIC TOOL FOR CLUSTER EVOLUTION STUDIES"

*E.F. Milone (RAO, U. of Calgary)*

The improvement of synthetic eclipsing light curve modeling codes over the past decade now permits simultaneous modeling in multiple passbands, radial velocities, and, to handle asymmetries, star spots. We have modified the Wilson-Devinney code by replacing its Carbon-Gingerich atmospheres option with one based on Kurucz's atmospheres. With empirical corrections of Buser and Kurucz, unprecedented accuracy in modeling UV light curves can now be carried out, and a diagnostic tool to probe chemical composition of systems in clusters is at hand. A simplex-unfolding version of the WD code can now probe parameter space and thus check the uniqueness of the WD least-squares solution. The contact system H235 in NGC 752 provides a timely example.

##### 2 MEMBERSHIPS AND THE BINARY POPULATION IN THE HYADES

*Robert P. Stefanik and David W. Latham, Harvard-Smithsonian Center for Astrophysics*

We have been monitoring the radial velocities of nearly all the proper-motion and photometric candidate members of the Hyades for almost a decade, from the F stars down to a V magnitude limit of almost 15. About 25% of the proper-motion candidates are not members, and therefore should not be included in any convergent-point solutions for the distance to the Hyades. We confirm that the transition period between circular and eccentric orbits for the main-sequence spectroscopic binaries is about 5.5 days. The frequency of spectroscopic binaries is consistent with the value of about 20% recently derived by the CORAVEL and CfA teams for various populations of field stars.

### 3 THE BINARY POPULATION IN M67

*David W. Latham, Harvard-Smithsonian Center for Astrophysics; Robert D. Mathieu, University of Wisconsin; Alejandra A. E. Milone, Harvard-Smithsonian Center for Astrophysics and University of Cordoba; Robert J. Davis, Harvard-Smithsonian Center for Astrophysics*

Precise radial velocity observations spanning almost 20 years have been used to derive spectroscopic orbits for 22 binaries brighter than  $V = 12.7$  in the field of the old open cluster M67 (Mathieu, Latham, and Griffin). All the binaries near the main sequence and with periods shorter than 11 days have circular orbits. This is consistent with tidal circularization being effective on the main sequence over the 5 Gyr age of the cluster.

Our original survey did not extend much below the cluster turn off, and evolutionary effects among the subgiants and giants complicate the tidal circularization arguments. To alleviate this ambiguity we are now extending our binary survey in M67 to a magnitude limit of nearly  $V = 16$ , well down the main sequence. We have identified about 45 new main-sequence binary candidates and have already derived preliminary orbits for 15 of these. The value we determine for the transition period remains unchanged. If there were no primordial binaries in M67, the core would have undergone gravothermal collapse in a time very short compared to the age of the cluster. Thus a knowledge of the population of main-sequence binaries is essential for N-body models of the dynamical evolution of the cluster.

### 4 MEMBERSHIP AND BINARY FREQUENCY FOR BLUE STRAGGLERS

*Alejandra A. E. Milone, Harvard Smithsonian Center for Astrophysics and University of Cordoba David W. Latham, Harvard-Smithsonian Center for Astrophysics*

We have attempted to measure the radial velocities of 62 candidate blue stragglers in the five open clusters NGC 752, 2360, 2420, 2682, and 7789 using the CFA systems on Mt. Hopkins; 42 of these candidates have yielded reliable velocities.

The unusually large population of blue straggler candidates in NGC 7789 has proven to be a result of serious contamination by non members.

Based on multiple velocity measurements over a few hundred days, we estimate that at least 40% of the blue stragglers that yield CFA velocities are binaries.

### 5 BINARY FREQUENCIES IN TWO OPEN CLUSTERS

*N. Morrell, Universidad Nacional de La Plata, and H. Abt, National Optical Astronomy Observatories*

A search for binaries was carried out among the brightest main sequence members of IC 4665 and the Alpha Persei cluster, through coudé-CCD spectroscopy (15 Å/mm) in order to compare binary frequencies in both clusters. For IC 4665, among 15 stars observed, we found 4 spectroscopic binaries (two double-lined) with periods ranging from 6 to 11 days. We observed 26 probable members of the Alpha Persei cluster, 3 of them are binaries (1 double-lined) and 4 are possible binaries (preliminary orbital solutions were found for 3 of them). All the periods are longer than 20 days, and the half-amplitudes lower than 13 km/s, which suggests relatively low-mass secondary components.

### 6 EVOLUTIONARY CHANGES IN BINARIES IN OPEN CLUSTERS

*H. Abt, National Optical Astronomy Observatories, and N. I. Morrell, Universidad Nacional de La Plata*

Originally we thought that binaries with  $P > 10$  years were formed by fission (because the secondary mass function was flat) and the longer ones by capture (because the secondaries fit the van Rhijn function). But fission does not work for compressible gases. We found that all characteristics of cluster and field binaries can be explained by capture alone. Simulations by Aarseth and Hills indicate that initially high-mass stars will form long-period binaries with low-mass stars because they are so plentiful, but after many captures and disruptions the high-mass stars tend to form short-period binaries with high-mass stars. That is consistent with the observations that in young clusters (Orion Neb., Alpha Persei) the mass ratios are all large and the periods are long, but after 10–100 free-fall times the mass ratios are mostly near 1 and the periods are shorter (as in IC 4665).

## 7 BINARITY AND MEMBERSHIP FROM CORAVEL RADIAL VELOCITY OBSERVATIONS IN OPEN CLUSTERS

*J.C. Mermilliod, Institut d'Astronomie de l'University de Lausanne*

Results of the systematic observing program in open clusters undertaken with the Coravel radial-velocity scanners at the Haute-Provence and La Silla (ESO) Observatories have been presented. It includes about Berenices, NGC 752, 6475, 7092, IC 2391 and 2602 and Blanco 1) and about 1000 red giants in 175 open clusters. The main motivations are the determination of membership, the determination of orbital elements and the study of their distribution, and the measurement of the rotation (dwarfs). Numerous binaries have been discovered and observed frequently. 50 orbits have been obtained so far for the dwarfs and 80 for the red giants. The overall frequency of spectroscopic binaries among the red giants is 23% (150 SB). The binary frequency in Praesepe seems to be twice that of the Pleiades in the interval F5–K0.

On July 30, Commission 37 organized a session on the subject of globular cluster ages. The Session was chaired by C. Pilachowski. Four papers were presented, as follows:

## 8 OLD CLUSTER AGES

*P. Demarque, Yale University*

The ages of the old star clusters provide basic information on the formation and evolution of the Galaxy. Recent advances indicate that an age spread of up to 4–5 Gyr exists among globular clusters, suggesting a long time scale of formation for the galactic halo. Absolute ages are more uncertain: current research focusses on the effects of helium diffusion near the main sequence turnoff, the dependence of the RR Lyrae luminosity on metallicity, and the [O/Fe] ratio in metal poor stars. For M92, the age is  $16 \pm 3$  Gyr. An age below 13 Gyr would cause inconsistencies with several other pieces of astronomical data.

Concerning the age of the old disk, it was pointed out that a solar calibration for the helium content and mixing-length of the turnoff stars in NGC 188 yields an age of 6–8 Gyr (depending on reddening) for the cluster. NGC 6791 is 1 Gyr older if of solar metallicity. If more metal rich than NGC 188, its age is reduced.

Finally, it was noted that recent data from Walker et al. on RR Lyrae variables in the galactic bulge, when compared to synthetic HB models (by Y.-W. Lee), suggest that the field RR Lyrae population in the bulge is 1–1.5 Gyr older than M92. The globular clusters may not contain the oldest stars in the Galaxy!

## 9 ALPHA ELEMENT ABUNDANCES IN THE DRACO DWARF SPHEROIDAL GALAXY

*J.E. Hesser, DAO/HIA/NRC*

In a program conducted with M.D. Lehnert, R.A. Bell and J.B. Oke, abundances have been measured for 14 giant stars with  $+0.2 < M_v < -2.5$  ( $19.6 < V < 16.9$ ) using Oke's double spectrograph equipped with CCD detectors on the 5-m Hale Telescope. A synthetic spectral analysis was performed of the calcium infrared triplet and the strongest line (5183 Å) of the magnesium 'b' triplet. Abundances inferred from the two elements correlate closely and range from  $-1.4$  to  $-2.4$ , with an average of  $-1.9 \pm 0.4$ . The abundances seem to fall into two groups, one with a  $\langle [Fe/H] \rangle = -1.6 \pm 0.2$  and the other with  $\langle [Fe/H] \rangle = -2.3 \pm 0.2$ . These results confirm and extend in several ways other claims for an abundance spread among the stars of the Draco Dsph; in particular they reach to much less evolved giants. It seems likely that the dominant factor in the color spread among giants in the color-magnitude diagram is the wide range of [Fe/H] at a given luminosity.

## 10 OXYGEN ABUNDANCES IN HALO STARS

*M. Bessell, Mt. Stromlo and Siding Spring Observatories*

The oxygen abundance has been determined for a sample of metal-poor G dwarfs ( $-1.2 < [Fe/H] < -2.7$ ) in two independent ways; by analysis of OH lines between 3080 - 3200 Å and the permitted high excitation far-red OI triplet (7771 - 7775 Å,  $c = 9.1eV$ ). The oxygen abundances determined from the low excitation OH lines are up to 0.55 dex lower than those measured from the high excitation OI lines. The abundances for the far-red OI triplet lines agree with those re-derived from Abia and Rebolo and the abundances

from the OH lines in dwarfs and giants are in agreement with the re-derived O abundances of Barbuy and others from the forbidden resonance OI line ( $6300\text{\AA}$ ,  $c = 0.0\text{eV}$ ). Because the  $c = 0 - 1.7\text{eV}$  OH lines are formed in the same layers as the majority of Fe, Ti and other neutral metal lines used for abundance analyses we believe that the OH lines and the forbidden OI line yield the true oxygen abundances relative to the metals. The most likely explanation for the systematic overabundances derived from high excitation lines is that metal-poor stars are much hotter in the deep layers where these lines are formed than are the model atmospheres used in the analyses. Discounting all far-red OI triplet abundances the behaviour of O/Fe with decreasing metallicity is very similar to that of the other alpha-elements, especially Ca, and shows a linear increase in [O/Fe] from 0 at [Fe/H] = 0 to +0.5 at around [Fe/H] = -2. [O/Fe] remains at about 0.5 dex for [Fe/H] between -2 and -4.

## 11 CNO ABUNDANCES IN GLOBULAR CLUSTERS

*C. A. Pilachowski and T. Armandroff, National Optical Astronomy Observatories*

New observations as well as published observations of carbon, nitrogen, and oxygen abundances in globular cluster stars are reviewed in order to pursue the questions of the original C+N+O abundance in unevolved stars in globular clusters, the variation of C+N+O from star to star within a cluster, and the role of  $O > N$  cycle processing in giants. We find that: 1) [C+N+O/Fe] is within the range 0.0 to +0.5 in globular clusters over a wide range in [Fe/H]; 2) [C+N+O/Fe] is constant within a cluster with the possible exceptions of omega Centauri and M22; 3) Log (O) vs Log (C+N) diagrams for the clusters M92, M13, M4, and 47 Tuc are consistent with the mixing of CNO processed material either in the star itself or in an earlier star, and 4) the constancy of [C+N+O/Fe] within clusters argues strongly that CN variations found in unevolved stars in clusters are not due to contamination by products of triple-alpha burning.

Commission 37 concluded its scientific program on July 31 with a variety of papers contributed on subjects related to globular and open clusters. The Session was compressed from 3 hours to only 90 minutes due to the fire in the San Martin Center that morning. The session was chaired by C. Pilachowski. The following individuals presented their work:

G. Meylan	"Two High Velocity Stars Ejected Out of 47 Tuc"
F. Graham-Smith	"10 Milli-Second Pulsar in 47 Tuc"
J. Colin	"Interaction between a Galactic Disc and a Globular Cluster"
D. Minniti	"Linear Polarization of Stars in 7 Metal Poor Globular Clusters"
J. C. Forte	"Dust in Globular Clusters"
I. Platais	"Luminosity Functions of Poorly Populated Open Clusters"
N. Nikolav	"Luminous Stars in Spiral Arms of M31"
R. Costero	"Origins of Runaway and Field O Stars"
A. J. Delgado	"Photometry of Young Open Clusters - NGC 1502 and NGC 2169"
E. Alfaro	"CCD BVR Photometry of the Open Cluster IC 1311"
M. Rabolli	"Globular Clusters in Fornax Ellipticals"
M. Tsvetkov	"Muenster-ESO Flare Star Search Project"

At the conclusion of this session Jean-Claude Mermilliod summarized recent progress with the Open Cluster Database.