Highlights of Astronomy, Vol. 13
International Astronomical Union, 2003
O. Engvold, ed.

Contributed Papers for JD4: Abstracts

Abundance Trends of Alpha and Fe-Peak Elements in Globular Clusters

Christopher Sneden

Abstract. A fairly large fraction of Galactic globular clusters have been subjected to some sort of high spectral resolution abundance analysis in the past two decades. Several clusters have enjoyed the scrutiny of large numbers (>20) of their giant stars at very high spectral resolution (R > 40,000) and signal-to-noise (>100), and such investigations have even begun to probe the fainter subgiant cluster members. Other clusters have seemed to be of lesser interest, having only studies of a few of their brighter members reported in the literature. This brief overview will consider the abundance trends of some key element groups, including the alpha, Fe-peak, neutron-capture, and proton-capture elements. Some comparison with field stars will be attempted to illustrate where stellar population differences between clusters and the field seem to occur. Suggestions for renewed observational attention will be drawn to specific clusters whose chemical origin appears to be substantially different than the general Galactic halo.

Abundances in Scarcely Evolved Stars in Globular Clusters

R. G. Gratton

Abstract. Abundances for stars on the main sequence and early subgiant branch (i.e. less evolved than the Red Giant Branch Bump) in globular clusters are reviewed. Emphasis is given to those elements that are involved in the Na-O and Mg-Al anticorrelations. Results obtained in the last few years clarified that very deep mixing (if any) cannot be the only cause of the abundance anomalies found in globular cluster stars. The new scenarios, calling for pollution by material processed in an earlier generation of stars, are briefly presented; the issues related to the lithium abundances are briefly commented.

Lithium Abundances in Globular Clusters

P. Bonifacio

Abstract. Warm metal–poor dwarf stars display a constant Li abundance, whichever their effective temperature or metallicity: the so-called "Spite Plateau". If this constant value represents the primordial Li abundance the Universal baryonic density may be derived by comparison to nucleosynthesis calculations. In recent years there has been an active debate on whether these stars have indeed preserved their pristine Li or whether it has been depleted by some stellar phenomenon. Since the Globular Clusters (GCs) are a homogeneous single-age population they are an ideal testing ground for any theory which predicts Li de-

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pletion. Recent observations of NGC 6397 ([Fe/H]~ -2.0) with the VLT/UVES show that there is no dispersion in Li abundances in excess of what expected from observational errors and that the Li content is the same as that of field stars. A re-analysis of extant data of M 92 ([Fe/H] ~ -2.3) shows that the intrinsic dispersion must be less than $\sim$ 0.2 dex. On the other hand for the more metal–rich GC 47 Tuc ([Fe/H]~ -0.7) VLT/UVES observations of 4 Turn Off (TO) stars suggest that a real dispersion in Li abundances exists. The conclusion is that the mechanism(s) which alter the Li abundance in TO stars are metallicity dependent and apparently ineffective at low metallicity.

On the Question of a Metallicity Spread in Globular Cluster M22 (NGC 6656)

I. I. Ivans, C. Sneden, G. Wallerstein, R. P. Kraft, J. E. Norris, J. P. Fulbright, & G. Gonzalez

Abstract. Results from early photometric and spectroscopic studies for M22 showed a metallicity spread similar to, albeit significantly smaller than, that found in ω Cen, the most massive cluster in our Galaxy. Numerous studies of M22 over the last few decades have yielded conflicting results: depending upon the sample and analysis techniques, some authors find no significant variations whereas others find metallicity variations of $\sim$0.5 dex. In our investigation of a sample of $\sim$30 stars, we are employing high resolution high signal-to-noise spectra and a variety of spectroscopic approaches in determining the stellar metallicities. In this contribution, we report some of the preliminary results from our investigation of the question of metallicity variations in M22, employing a set of models derived by applying chemical constraints.

The Metallicity and Age Ranges in ω Centauri

Laura M. Stanford, Gary S. Da Costa, John E. Norris, & R. D. Cannon

Abstract. We present a metallicity distribution and an age-metallicity relation for the globular cluster ω Centauri based on photometry and spectra of members at the Main Sequence Turnoff (MSTO) region of the color-magnitude diagram. The age-metallicity relation was determined by two independent methods. These preliminary results show that the formation of the cluster took place over an extended period of at least 4 Gyrs with the more metal-rich stars being younger. We find no metal-rich old or metal-poor young stars in our sample of 446 ω Cen members.

A Comparison of Globular Cluster and Field Halo Stars

Robert P. Kraft (Delivered by Christopher Sneden)

Abstract. Abundances of the light elements O, Na, Mg, and Al in giants of four globular clusters having [Fe/H] ~ -1.6, are compared with halo field giants having [Fe/H] between -1.0 and -2.5. The last named reflect the abun-

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dances expected in Type II supernova ejecta. Abundance anomalies among these elements, resulting from proton capture synthesis, increase in severity along a "sequence" corresponding to "halo field", NGC 7006, M3, NGC 6752 and finally M13. The results are discussed in terms of deep mixing vs primordial scenarios as well as impact on the so-called second parameter problem.

General Discussion I: At What Stage is the Abundance Determination Problem?

Beatriz Barbuy (Discussion Chair)

Abstract. This open session concentrates on the major problems of abundance determinations, and for this, the effective temperature determination is discussed by Mike Bessell, the use of FeI and FeII lines and excitation and ionization equilibrium is discussed by Verne Smith. Roger Cayrel discusses the use of 1-D model atmospheres with different values of the mixing length parameter, and its impact on OI lines. Martin Asplund discusses the results of using 3-D model atmospheres and NLTE effects.

The Temperature Scale of Globular Cluster Stars

Michael S. Bessell

Abstract. The empirical temperature scale for Pop I A-K stars has been well established for over 20 years from application of stellar intensity interferometry, lunar occultation, infra-red flux method and Michelson interferometry. Line-blanketed model atmospheres and a better understanding of the handling of convection now produce synthetic colors that are in excellent agreement with this empirical temperature scale. Model atmosphere colors and fluxes for higher and lower abundances than solar can be used confidently to derive temperatures for the globular cluster stars.

Globular Cluster Abundances in the Light of 3D Hydrodynamical Model Atmospheres

Martin Asplund

Abstract. The new generation of 3D hydrodynamical model atmospheres have been employed to study the impact of a realistic treatment of stellar convection on element abundance determinations of globular cluster stars for a range of atomic and molecular lines. Due to the vastly different temperature structures in the optically thin atmospheric layers in 3D metal-poor models compared with corresponding hydrostatic 1D models, some species can be suspected to be hampered by large systematic errors in existing analysis. In particular, 1D analysis based on minority species and low excitation lines may overestimate the abundances by > 0.3 dex. Even more misleading may be the use of molecular lines for metal-poor globular clusters. However, the prominent observed abundance (anti-)correlations and cluster variations are largely immune to the choice of model atmospheres.

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Oxygen Abundance and Convection

C. Van'tVeer, & R. Cayrel

Abstract. The triplet IR lines of O I near 777 nm are computed with the Kurucz's code, modified to accept several convection models. The program has been run with the MLT algorithm, with l/H = 1.25 and 0.5, and with the Canuto-Mazzitelli and Canuto-Goldman-Mazzitelli approaches, on a metal-poor turnoff-star model atmosphere with Teff = 6200 K, log g = 4.3, [Fe/H]= –1.5. The results show that the differences in equivalent widths for the 4 cases do not exceed 2 per cent (0.3 mA). The convection treatment is therefore not an issue for the oxygen abundance derived from the permitted lines.

Population III Supernovae and their Nucleosynthesis

K. Nomoto, K. Maeda, H. Umeda, N. Tominaga, T. Ohkubo, J. Deng, & P. A. Mazzali

Abstract. Stars more massive than $\sim$ 20 - 25 $M_\odot$ form a black hole at the end of their evolution. Stars with non-rotating black holes are likely to collapse "quietly" ejecting a small amount of heavy elements (Faint supernovae). In contrast, stars with rotating black holes are likely to give rise to very energetic supernovae (Hypernovae). We present distinct nucleosynthesis features of these two types of "black-hole-forming" supernovae. Nucleosynthesis in Hypernovae is characterized by larger abundance ratios (Zn,Co,V,Ti)/Fe and smaller (Mn,Cr)/Fe than normal supernovae, which can explain the observed trend of these ratios in extremely metal-poor stars. Nucleosynthesis in Faint supernovae is characterized by a large amount of fall-back. We show that the abundance pattern of the recently discovered most Fe-poor star, HE0107-5240, and other extremely metal-poor carbon-rich stars are in good accord with those of black-hole-forming supernovae, but not pair-instability supernovae. This suggests that black-hole-forming supernovae made important contributions to the early Galactic (and cosmic) chemical evolution. Finally we discuss the nature of First (Pop III) Stars.

The Role of AGB Stars

John Lattanzio, Amanda Karakas, Simon Campbell, Lisa Elliott, & Alessandro Chieffi

Abstract. We give a brief summary of the abundance anomalies seen in globular cluster stars, and try to review how and if AGB stars could be responsible. The abundance anomalies are clearly indicative of hot H burning, such as is expected during hot bottom burning in intermediate mass AGB stars. Nevertheless, we conclude that a quantitative fit is very hard to obtain using current AGB models.

https://doi.org/10.1017/S1539299600015458 Published online by Cambridge University Press

Today's AGB Stars and the Role of Binaries

Pavel A. Denissenkov

Abstract. Recent observations of the star-to-star abundance variations well below the bump luminosity in globular clusters have raised the weight of the primordial scenario. So far, intermediate-mass AGB stars have been considered as the most likely primordial sources of these abundance variations. I present some arguments against this idea and propose alternative sources. These are RGB and/or AGB stars a little bit more massive than the present-day MSTO stars that had experienced enhanced extra mixing in the past. In this case the more preferable way of polluting the lower mass MS stars by nuclearly processed material would be mass transfer in binaries rather than stellar winds from single stars.

New AGB Models to Explore the Spread of Abundances in Globular Clusters

Paolo Ventura, Francesca D'Antona, & Italo Mazzitelli

Abstract. Following the line of thought that the inhomogeneities in composition of GC stars are due to contamination from the ejecta of the massive AGBs which evolved in the first 100-200Myr, we must study in detail the production of elements during the AGB evolution. The study requires computation of complete stellar models including nuclear processing by Hot Bottom Burning, coupled with non-instantaneous mixing for as many elements as possible. These models are still subject to many uncertainties, so that the additional hypothesis that the spreads in abundances are not random, but can be attributed to the existence of several different generation of stars directly formed from AGB ejecta, provides a powerful tool to constrain the efficiency of Hot Bottom Burning and the role of the third dredge up. We show that many difficulties are still present in this scenario, in particular our recent models confirm that the anticorrelation Na–O is not well explained. If the spreads are indeed due to different stellar generations, however, we can use the abundance anomalies to understand better the AGB models.

Processes at the Turnoff

Georges Michaud, Olivier Richard, & Jacques Richer

Abstract. Stellar evolution models taking into account the atomic diffusion of 28 species, have been calculated for Pop II stars of 0.5 to 1.2 $M_\odot$ with [Fe/H] from −4.31 to −0.71. Overabundances are expected in some turnoff stars with $T_{eff} \geq 5900$ K. They depend strongly on the metallicity of the cluster. At the metallicity of M 92, they reach a factor of 10 for many species, at 12 Gyr, but a factor of at most 2, at 13.5 Gyr. Series of models were also calculated with turbulence to determine to what extent it reduces predicted abundance anomalies. The level of abundance anomalies observed in turnoff stars may then determine a level of turbulence. Even in the presence of turbulence however,

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allowance for diffusive processes leads to a 10%-12% reduction in age at a given turnoff luminosity. For M 92 an age of 13.5 Gyr is determined.

Mixing along the Red Giant Branch

Achim Weiss, & Corinne Charbonnel

Abstract. We review canonical mixing in low-mass stars on the Red Giant Branch, the evidence for additional – extra – mixing based on observations of chemical abundance trends and anomalies, discuss the connection with the Red Giant bump and with proton-nucleosynthesis, and the current understanding of the connection between extra-mixing and differential rotation. New developments concerning the sequence of events leading to the observed abundances are included, too.

General Discussion II: On Current Stellar Models

Don A. VandenBerg (Discussion Chair)

Abstract. Given the emphasis at this meeting on stellar models that treat diffusive and deep-mixing processes, as well as on recent computations for the AGB phase, a panel of experts was organized to further discuss the comparisons between theory and observations, the limitations of current models, and anticipated future advances. G. Michaud provided further insights on which stars are expected to show the largest abundance anomalies due to gravitational settling and radiative accelerations, and on the role of turbulent mixing. A. Weiss emphasized the importance of fully understanding diffusive processes and of investigating the still largely untested consequences of such processes (and deep mixing) for the late evolutionary phases of stars. S. Vauclair reported on the possible interaction between meridional circulation currents and diffusion, which could potentially explain why the observed abundance anomalies are less than those predicted by diffusive models. P. Denissenkov briefly reviewed several of the main problems that need to be solved in order to achieve an understanding of the observed abundances in giant stars, including the identification of the physical mechanism of deep mixing and an understanding of how the rotation profile in stars evolves. F. D'Antona outlined the reasons why she believes that massive AGB stars are the source of the material that produces the observed abundances in globular cluster stars (via pollution), including, in particular, the constraints provided by the observed Li abundances. Finally, J. Lattanzio commented that deep mixing is likely restricted to the upper giant branch and that some kind of primordial mechanism must be found to explain the abundance anomalies in less evolved stars: he also reminded us of some difficulties with the AGB scenario. Short contributions from each of the above are included in this paper.

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Formation of Stars in Clusters

Bruce Elmegreen

Abstract. Models of star formation in clusters and some of their observational constraints are reviewed. The formation of old globular cluster stars probably proceeded in a similar fashion to the formation of stars in today's young massive clusters, considering their similar IMF's, stellar densities, and masses. The dominant mechanism for star formation would then be collapse following energy dissipation and gravitational instabilities in a compressible turbulent medium. The formation of the halo globulars themselves occurred in a peculiar environment, however, where the microwave background temperature was higher than it is today by a factor of 3 to 10, the pressure from the potential well of the protogalaxy was larger than in today's galaxy disks by a factor of > 100, the mean magnetic field was probably lower by at least an order of magnitude without an active dynamo, the metallicity was lower by $\sim 1/40$, and non-thermal radiation from QSOs and other nuclear activity was important. These differences must have had several important consequence for star formation even though the basic physical processes were the same. The most important consequence seems to be that the epoch of globular cluster formation was the first time in the history of the Universe when cooling was strong enough and the microwave temperature small enough to produce a thermal Jeans mass that was less than a solar mass given the typical pressure of the environment. This small thermal Jeans mass allowed the cluster to remain bound over a Hubble type without severe mass loss from stellar winds and supernovae, and it allowed most of the stars in the cluster to shine for a Hubble time without turning off the main sequence. Other star and cluster formation from earlier times could not have produced such long-lasting objects as the halo globular clusters. Globular clusters are the result of a selection effect for survival over a Hubble time.

Globular Cluster Formation from Cloud-Cloud Collisions

T. Shigeyama, & T. Tsujimoto

Abstract. Hydrodynamic evolution of supernova remnants in collided proto-cluster clouds is investigated in the frame work of a supernova-driven star formation scenario. It is found that the relative velocity of proto-clouds must be greater than a certain value, which is a function of the mass of each proto-cloud, to produce a stellar cluster with little dispersion of [Fe/H] ratios among the member stars. The metallicity distribution function for globular clusters in the Galactic halo is calculated from a simple model. This calculation shows that cloud-cloud collisions can reproduce the observed metallicity distribution function for globular clusters. Before cloud-cloud collisions, each cloud has been enriched with heavy elements according to a supernova-driven star formation scenario that reproduces the observed abundance distribution function for the Galactic halo field stars.

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Globular Cluster Abundance Anomalies: Clues from the Main Sequence

G. S. Da Costa, Russell Cannon, Barry Croke, & John Norris

Abstract. We present an analysis of spectra of a large sample of main sequence stars in the globular cluster 47 Tuc observed with the 2dF multi-fibre instrument on the Anglo-Australian Telescope. The spectra confirm that anti-correlated variations in the strengths of the CN and CH bands exist among the main sequence stars in this cluster. Further, the ratio of CN-strong to CN-weak stars on the main sequence is identical, to within the statistics, to the value for the red giant branch. This strongly implies that evolutionary (mixing) processes do not play a significant role in generating the abundance anomalies observed in this cluster. We also find that the strengths of the sodium-D lines in the spectra of these main sequence stars correlate positively with the cyanogen band strength index. We then compare our 47 Tuc results to those for main sequence stars in M71, a globular cluster of comparable abundance to 47 Tuc, and to those for main sequence stars in the more metal-poor globular cluster M13.

The Horizontal Branch Morphology in Globular Clusters: Consequences for the Self-Pollution Model

Francesca D'Antona

Abstract. The Joint Discussion 4 of the Sydney IAU General Assembly takes place at a very interesting stage for Globular Cluster (GC) astrophysics, when it is becoming clear that many –if not all– of the inhomogeneities in the chemical composition of GC stars are due to some mechanism of primordial enrichment. The best candidate for "self-pollution" is identified with the matter lost in winds of low velocity from Asymptotic Giant Branch (AGB) stars, especially of high mass, evolving during the first phases of the life of the Clusters, and cycling their envelope material through the hot-CNO cycle at the bottom of their convective envelopes (Hot Bottom Burning – HBB). Recognition that Globular Clusters showing large chemical anomalies are also peculiar in their Horizontal Branch (HB) star distributions, led D'Antona et al. (2002) to suggest that extended blue tails are directly linked to enhanced helium in the matter, processed through HBB, from which these stars are born. Here we show that other HB peculiar morphologies –such as the lack of stars in the RR Lyrae region, in clusters like NGC 2808, whose red and blue side of the HB are both well populated– can be attributed to the helium enrichment of the matter from which the stars populating the whole blue HB in this cluster were born. This interpretation lends credit to the idea that the GC stars are formed in two main generations, the first one having the composition of the primordial gas cloud, the second one formed *directly* from the AGB ejecta over a span of time lasting $\sim 2 \times 10^8$ yr. This hypothesis provides a useful and conceptually simple key not only to interpret some –but not all– HB peculiarities, but also to understand the distribution of abundance anomalies. If the model is correct, in the end we can use the abundance anomalies to falsify (or calibrate) our AGB models.

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General Discussion III: Chemistry and Self–Pollution Mechanisms
R. Cayrel (Discussion Chair)

Abstract. Round table 3 was devoted to the origin of chemical anomalies found in a significant fraction of stars in GCs, but not in field metal-poor stars of similar metallicity. Formerly a hot topic was if such anomalies, studied only in giant stars, bright enough to allow reliable abundance determinations, were generated in the course of the evolution of the star, or inherited at the birth of the star. The ESO Large Program led by R. Gratton has demonstrated, without ambiguity, that the most famous of these "anomalies", the O-Na anticorrelation, was already present in turn-off (TO) stars, therefore already there at the birth of the star. This does not preclude that some modifications occur along the red giant branch, as described, for example, already in Charbonnel (1994), but those are well identified and do not include the O-Na anticorrelation, but affect mostly ^{12}C,^{13}C, ^{14}N and Li. More recently, models including rotation in the evolution (see for example talks by Charbonnel and Weiss at JD 4) have been produced. The most promising process for explaining the O-Na anticorrelation is the hot-bottom-burning process (HBB) in TP-AGBs, Ventura et al. (2001). The problem remaining is the transfer of the processed matter to an unevolved star. Here, several routes exist, and so far no consensus has been reached on those which are dominant. Roundtable 3 was expected to supply a live discussion between the proponents of the various ideas emitted on this subject. Unfortunately, in the time allotted, the only thing which appeared possible was to suggest tests for evaluating the coherency of the various proposals, against the widest set of observational constraints. For example, the HBB produces an enrichment in helium, potentially affecting the isochrones. Very accurate observations could try to detect this side-effect. Transfer of mass from an AGB to an unevolved companion is an efficient way of pollution. But it is then expected that the remaining binary shows a variable radial velocity (unless the pair has been disrupted afterwards...). At the other extreme, the mass loss of AGBs may have been large enough to have produced a second generation in a GC (see F. d'Antona contribution). But let us leave their role to our participants...

The AGB Contamination Scenario
Achim Weiss

Abstract. *Proposed tests.* The primordial scenario suggested by D'Antona, Gratton, and others, which assigns the observed ONa-anticorrelation and the Mg- and Al-anomalies in cluster red giants to processes in thermally pulsing, hot bottom-burning AGB stars of an earlier generation, has many attractive features. The models also make clear predictions concerning the initial composition of those stars we see today as red giants. These predictions should be tested with stellar models using the predicted initial composition, which is helium-enriched. One can, for example, check, whether the subgiant branch, during which the effectiveness of the hydrogen-shell (i.e. the abundance of CNO) is important, or the location and extent of the bump are affected; whether there are photometric

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differences between "normal" and "AGB-contaminated" stars, even if so far the isochrones appear to be indistinguishable. Observationally, a determination of the luminosity function and the distribution of stars of both types towards the tip of the RGB should be done, because the initial helium content will affect both. It is also necessary to investigate closer the nucleosynthesis of AGB stars of interest, because I think that no agreement has been reached here concerning the production/destruction of certain elements (Na, Mg and its isotopes) as function of mass, metallicity, etc. We need to be able to define robust results, which can guide future observations.

Contribution to JD4 Round Table Discussion 3

G. S. Da Costa

Abstract. In my contribution to the roundtable discussion I drew attention to what I see as two key questions relevant to the debate concerning the relative importance of processes occurring early in the life of a globular cluster ("primordial processes") and processes occurring in the stars we observe today ("mixing processes"). These are: (1) In a given cluster, is the total abundance of C+N+O constant from star-to-star, even though the individual C, N and O abundances vary substantially? We don't have a definite answer here but it is a vital question since constant C+N+O is a necessary outcome of any mixing process. (2) In a given cluster, is it really reasonable to imagine that all the 'second generation' stars can be formed from the ejecta of AGB stars? At this meeting we have frequently heard the suggestion that the Nitrogen- and Sodium-rich, Carbon- and Oxygen-poor stars may have been formed from the mass lost by thermally-pulsing upper-AGB stars. I think we are now in a position where we could attempt to quantitatively evaluate this question for a cluster like 47 Tucanae. It may be that such a requirement can only be filled with a rather unusual mass function for the 'first generation', a point first made long ago by Smith & Norris (1984).

Abundance Anomalies and Lithium in Globular Clusters

P. Bonifacio

Abstract. Since Li is destroyed at temperatures above 2.5×10^6K its abundance may be a useful diagnostic for the nuclear history of the material observed in a stellar atmosphere. It is therefore interesting to note what are the correlations (if any) between Li abundances and abundance anomalies.

A Discussion of Self-Pollution Mechanisms

P. A. Denissenkov

Abstract. Intermediate-mass AGBs and low-mass stars having just passed the helium-flash are both potential contributors to chemical variations in GC stars. Both mechanisms face the difficulty of the short time available between sweeping the generated gas at each crossing of the galactic plane by the GCs.

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Can we Build up Second Generation Stars in GCs Directly from the Ejecta of AGBs?
Francesca D'Antona

Abstract. My contribution to the round table on chemistry and self-pollution mechanisms examines the consequences behind the hypothesis of globular clusters are made up by a first stellar generation plus a second, long stage of star formation, lasting some 200Myr, directly from the ejecta of AGB stars.

The Summaries below are of the poster presentations.

B. Barbuy, J. Meléndez, S. Ortolani, M. Zoccali, E. Bica, A. Renzini, V. Hill, Y. Momany, D. Minniti, & M. Rich: Abundance Analysis of the Bulge Globular Clusters NGC 6553 and NGC 6528

A detailed abundance analysis of 5 giants of the metal-rich bulge globular cluster NGC 6553 was carried out using high resolution infrared spectra in the H band, obtained at the Gemini-South 8m telescope. High resolution spectra of 3 stars in the bulge globular cluster NGC 6528 were obtained at the 8m VLT UT2-Kueyen telescope with the UVES spectrograph. The present analysis provides a metallicity $[Fe/H] = -0.15 \pm 0.2$ and $[\alpha/Fe] \approx +0.2$ for NGC 6528, and $[Fe/H] = -0.20 \pm 0.10$ and an oxygen overabundance of $[O/Fe] = +0.20$ for NGC 6553, resulting in an overall metallicity $Z \approx Z_{\odot}$ for both clusters.

Uta Fritze – v. Alvensleben: Stellar Abundances in Young and Intermediate Age GCs

Globular Cluster (**GC**) formation seems to be a widespread mode of star formation in extreme starbursts triggered by strong interactions and mergers of massive gas-rich galaxies. We use our detailed chemically consistent evolutionary synthesis models for spiral galaxies to predict stellar abundances and abundance ratios of those second generation GCs as a function of their age or formation redshift. Comparison with observed spectra of young star clusters formed recently in an ongoing interaction (NGC 4038/39) and a merger remnant (NGC 7252) are encouraging. Abundances and abundance ratios (and their respective spreads) among young and intermediate cluster populations and among the red peak GCs of elliptical/S0 galaxies with bimodal GC color distributions are predicted to bear a large amount of information about those clusters' formation processes and environment. Not only the bright young clusters but also representative populations of "old" GCs in E/S0 galaxies are readily accessible to MOS on 10m class telescopes.

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Jennifer A. Johnson: A Survey for CH Stars in Globular Clusters

To determine the frequency of CH stars in metal-poor globular clusters, I have begun a survey using intermediate-band photometry and low-dispersion spectroscopy. In the preliminary analysis of one cluster, M 30, I have found that the photometry successfully selects stars with strong G-bands, while the low-dispersion spectra isolate those stars with the correct metallicities and radial velocities to be cluster members. In the M 30 sample, I have found three stars that have stronger G-bands than normal cluster stars of the same luminosity.

L. Sbordone, P. Bonifacio, G. Marconi, & R. Buonanno: Chemical Abundances in Terzan 7 from UVES spectra

We present abundances for Mg, Si, Ca, Fe, and Ni for 3 giants in the sparse globular cluster Terzan 7, physically associated with the Sagittarius Dwarf Spheroidal Galaxy (Sgr dSph), which is presently being tidally disrupted by the Milky Way. Sgr dSph shows signs of a prolonged and peculiar star formation history, (low α content, high metallicity, significant Na, Co, Ni underabundance). Our data, obtained with VLT-UVES, show a mean [Fe/H]$= -0.57$, solar-scaled α elements ($[\alpha/\mathrm{Fe}]\sim 0$) and a significant Ni underabundance ([Ni/Fe]$= -0.2$). These results are strikingly resembling what we find in the body of the Sgr dSph. This enforces the membership of Terzan 7 to the Sgr dSph system. In fact, a clear chemical pattern can be traced in the $[\alpha/\mathrm{Fe}]$ vs [Fe/H] plane including the Sgr dSph, the associated clusters Ter 7 and M54, the clusters Pal 5 and Pal 12, and the young globular Ru 106. This last system is also known to show a similar Ni underabundance, never found elsewhere in the Milky Way. Note that Pal 12 and Pal 5 are believed to have been originated inside the Sgr dSph system, while Ru 106 is suspected to have been also accreted from another merging episode.

Takuji Tsujimoto, & Toshikazu Shigeyama: Star Formation History of Omega Centauri

The star formation history of the globular cluster Omega Centauri is investigated in the context of an inhomogeneous chemical evolution model in which supernovae induce star formation. The proposed model explains recent observations for Omega Cen stars and divides star formation into three epochs. The formation of Omega Cen is also discussed in the framework of globular cluster formation triggered by cloud-cloud collisions. In this scenario the relative velocity of clouds in the collision determines the later chemical evolution in the clusters. A head-on collision of proto-cluster clouds with a low relative velocity would have converted less than 1% of gas into stars and promoted the subsequent chemical evolution by supernova-driven star formation. This is consistent with present observed form of Omega Cen. In contrast the other Galactic globular clusters are expected to have formed from more intense head-on collisions and the resultant clouds would have been too thin for supernovae to accumulate enough gas to form the next generation of stars. This explains the absence of chemical evolution in these other globular clusters.

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