The Star Clusters Young & Old Newsletter

edited by Giovanni Carraro, Martin Netopil, and Ernst Paunzen
http://www.univie.ac.at/scyon/
email: scyon@univie.ac.at

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Dear colleagues,

With this issue we want to introduce a new section of the newsletter that provides summaries of past conferences that are closely related to stellar clusters. During summer time several conferences took place and we thank the organizers of two of them to provide such a summary for this issue. This is certainly of interest in particular for those who were not able to participate. We also want to draw your attention to the approaching deadline (15^{th} Sept.) to submit Letters of Intent for proposing IAU symposia in 2018. We encourage the community to submit cluster related topics, because the currently last one took place in 2015 (IAUS 316: Formation, evolution, and survival of massive star clusters).

This issue includes 20 refereed abstracts that cover a broad range of topics in stellar cluster research. There is also the Ph.D. abstract by Neven Vulic included, and we would like to take this opportunity to congratulate him for the work "X-ray Populations in The Local Group: Insights with *Hubble* and *Chandra*".

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About the Newsletter

SCYON publishes abstracts from any area in astronomy, which are relevant to research on star clusters. We welcome all kinds of submitted contributions (abstracts of refereed papers or conference proceedings, PhD summaries, and general announcements of e.g. conferences, databases, tools, etc.)

The mission of this newsletter is to help all the researchers in the field with a quick and efficient link to the scientific activity in the field. We encourage everybody to contribute to the new releases! New abstracts can be submitted *at any time* using the **webform** on the SCYON homepage.

http://www.univie.ac.at/scyon

Star Forming Regions

New detections of embedded clusters in the Galactic halo

D. Camargo, E. Bica, and C. Bonatto
Universidade Federal do Rio Grande do Sul, Departamento de Astronomia, Porto Alegre, Brazil

Until recently it was thought that high Galactic latitude clouds were a non-star-forming ensemble. However, in a previous study we reported the discovery of two embedded clusters (ECs) far away from the Galactic plane ($\sim$ 5 kpc). In our recent star cluster catalogue we provided additional high and intermediate latitude cluster candidates. This work aims to clarify whether our previous detection of star clusters far away from the disc represents just an episodic event or whether star cluster formation is currently a systematic phenomenon in the Galactic halo. We analyse the nature of four clusters found in our recent catalogue and report the discovery of three new ECs each with an unusually high latitude and distance from the Galactic disc midplane. The analysis is based on 2MASS and WISE colour-magnitude diagrams (CMDs), and stellar radial density profiles (RDPs). The CMDs are built by applying a field-star decontamination procedure, which uncovers the cluster's intrinsic CMD morphology. All of these clusters are younger than 5 Myr. The high-latitude ECs C 932, C 934, and C 939 appear to be related to a cloud complex about 5 kpc below the Galactic disc, under the Local arm. The other clusters are above the disc, C 1074 and C 1100 with a vertical distance of $\sim$3 kpc, C 1099 with $\sim$2 kpc, and C 1101 with $\sim$ 1.8 kpc. According to the derived parameters ECs located below and above the disc occur, which gives evidence of widespread star cluster formation throughout the Galactic halo. This study therefore represents a paradigm shift, by demonstrating that a sterile halo must now be understood as a host for ongoing star formation. The origin and fate of these ECs remain open. There are two possibilities for their origin, Galactic fountains or infall. The discovery of ECs far from the disc suggests that the Galactic halo is more actively forming stars than previously thought. Furthermore, since most ECs do not survive the infant mortality, stars may be raining from the halo into the disc, and/or the halo may be harbouring generations of stars formed in clusters like those detected in our survey.

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`http://adsabs.harvard.edu/abs/2016arXiv160700672C`

A cautionary note about composite Galactic star formation relations

G. Parmentier
Astronomisches Rechen-Institut, Zentrum für Astronomie, Heidelberg, Germany

We explore the pitfalls which affect the comparison of the star formation relation for nearby molecular clouds with that for distant compact molecular clumps. We show that both relations behave differently in the (Σ_{gas}, Σ_{SFR}) space, where Σ_{gas} and Σ_{SFR} are, respectively, the gas and star-formation rate surface densities, even when the physics of star formation is the same. This is because the star-formation relation of nearby clouds relates gas and star surface densities measured locally, that is, within a given interval of gas surface density, or at a given protostar location. We refer to such measurements as local measurements, and the corresponding star-formation relation as the local relation. In contrast, the stellar content of a distant molecular clump remains unresolved. Only the mean star-formation rate can be obtained from e.g. the clump infrared luminosity. One clump therefore provides one single point to the (Σ_{gas}, Σ_{SFR}) space, that is, its mean gas surface density and star-formation rate surface density. We refer to this star-formation relation as a global relation since it builds on the global properties of molecular clumps. Its definition therefore requires an ensemble of cluster-forming clumps. We show that, although the local and global relations have different slopes, this per se cannot be taken as evidence for a change in the physics of star-formation with gas surface density. It therefore appears that great caution should be taken when physically interpreting a composite star-formation relation, that is, a relation combining together local and global relations.

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`http://adsabs.harvard.edu/abs/2016ApJ...826...74P`

Galactic Open Clusters

CCD UBV Photometry and Kinematics of the Open Cluster NGC 225

S. Bilir [1], Z. F. Bostanci [1], T. Yontan [2], and 6 co-authors

([1]) Istanbul University, Faculty of Science, Department of Astronomy and Space Sciences, Istanbul, Turkey; ([2]) Istanbul University, Graduate School of Science and Engineering, Department of Astronomy and Space Sciences, Istanbul, Turkey

We present the results of CCD UBV photometric and spectroscopic observations of the open cluster NGC 225. In order to determine the structural parameters of NGC 225, we calculated the stellar density profile in the cluster's field. We estimated the probabilities of the stars being physical members of the cluster using the existing astrometric data. The most likely members of the cluster were used in the determination of the astrophysical parameters of the cluster. We calculated the mean radial velocity of the cluster as $V_r = 8.3 \pm 5.0$ km s^{-1} from the optical spectra of eight stars in the cluster's field. Using the $U-B$ vs $B-V$ two-colour diagram and UV excesses of the F-G type main-sequence stars, the reddening and metallicity of NGC 225 were inferred as $E(B-V) = 0.151 \pm 0.047$ mag and [Fe/H]=0.11 ± 0.01 dex, respectively. We fitted the colour-magnitude diagrams of NGC 225 with the PARSEC isochrones and derived the distance modulus, distance and age of the cluster as $\mu_V = 9.3 \pm 0.07$ mag, d=585±20 pc and $t = 900 \pm 100$ Myr, respectively. We also estimated the galactic orbital parameters and space velocity components of the cluster and found that the cluster has a slightly eccentric orbit of $e = 0.07 \pm 0.01$ and an orbital period of $P_{orb} = 255 \pm 5$ Myr.

Accepted by : Advances in Space Research
`http://adsabs.harvard.edu/abs/2016arXiv160608608B`

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The Gaia-ESO Survey: pre-main-sequence stars in the young open cluster NGC 3293

A. J. Delgado [1], L. Sampedro [1], E. J. Alfaro [1], and 31 co-authors

([1]) Instituto de Astrofísica de Andalucía (IAA-CSIC), Glorieta de la Astronomía, Granada, Spain

The young open cluster NGC3293 is included in the observing program of the Gaia-ESO survey (GES). The radial velocity values provided have been used to assign cluster membership probabilities by means of a single-variable parametric analysis. These membership probabilities are compared to the results of the photometric membership assignment of NGC3293, based on UBVRI photometry. The agreement of the photometric and kinematic member samples amounts to 65 per cent, and could increase to 70 per cent as suggested by the analysis of the differences between both samples. A number of photometric PMS candidate members of spectral type F are found, which are confirmed by the results from VPHAS photometry and SED fitting for the stars in common with VPHAS and GES data sets. Excesses at mid- and near-infrared wavelengths, and signs of H emission, are investigated for them. Marginal presence of H emission or infilling is detected for the candidate members. Several of them exhibit moderate signs of U excess and weak excesses at mid-IR wavelengths. We suggest that these features originate from accretion discs in their last stages of evolution.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://adsabs.harvard.edu/abs/2016MNRAS.460.3305D`

The OPD Photometric Survey of Open Clusters II. robust determination of the fundamental parameters of 24 open clusters

H. Monteiro, W. S. Dias, G. R. Hickel, and T. C. Caetano
Universidade Federal de Itajubá, Instituto de Física e Química, Itajubá-MG, Brazil

In the second paper of the series we continue the investigation of open cluster fundamental parameters using a robust global optimization method to fit model isochrones to photometric data. We present optical UBVRI CCD photometry (Johnsons-Cousins system) observations for 24 neglected open clusters, of which 14 have high quality data in the visible obtained for the first time, as a part of our ongoing survey being carried out in the 0.6m telescope of the Pico dos Dias Observatory in Brazil. All objects were then analyzed with a global optimization tool developed by our group which estimates the membership likelihood of the observed stars and fits an isochrone from which a distance, age, reddening, total to selective extinction ratio R_V (included in this work as a new free parameter) and metallicity are estimated. Based on those estimates and their associated errors we analyzed the status of each object as real clusters or not, finding that two are likely to be asterisms. We also identify important discrepancies between our results and previous ones obtained in the literature which were determined using 2MASS photometry.
The code can be downloaded from: `https://github.com/hektor-monteiro/OC_CEfit/releases`

Accepted by : New Astronomy
`http://arxiv.org/abs/1608.03010`

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X-ray and optical spectroscopy of the massive young open cluster IC 1805

G. Rauw and Y. Naze
Université de Liège, Liège, Belgium

Very young open clusters are ideal places to study the X-ray properties of a homogeneous population of early-type stars. In this respect, the IC 1805 open cluster is very interesting as it hosts the O4If+ star HD 15570 thought to be in an evolutionary stage intermediate between a normal O-star and a Wolf-Rayet star. Such a star could provide a test for theoretical models aiming at explaining the empirical scaling relation between the X-ray and bolometric luminosities of O-type stars. We have observed IC 1805 with XMM-Newton and further collected optical spectroscopy of some of the O-star members of the cluster. The optical spectra allow us to revisit the orbital solutions of BD+60° 497 and HD 15558, and provide the first evidence of binarity for BD+60° 498. X-ray emission from colliding winds does not appear to play an important role among the O-stars of IC 1805. Notably, the X-ray fluxes do not vary significantly between archival X-ray observations and our XMM-Newton pointing. The very fast rotator BD+60° 513, and to a lesser extent the O4If+ star HD 15570 appear somewhat underluminous. Whilst the underluminosity of HD 15570 is only marginally significant, its amplitude is found to be compatible with theoretical expectations based on its stellar and wind properties. A number of other X-ray sources are detected in the field, and the brightest objects, many of which are likely low-mass pre-main sequence stars, are analyzed in detail.

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`http://arxiv.org/abs/1608.04499`

Stellar populations in the Carina region: The Galactic plane at l=291

J.A. Molina-Lera [1], G. Baume [1,2], R. Gamen [1,2], E. Costa [3], and G. Carraro [4,5]

([1]) Instituto de Astrofísica de La Plata (CONICET, UNLP), Argentina; ([2]) Facultad de Ciencias Astronómicas y Geofísicas (UNLP), Argentina; ([3]) Departamento de Astronomía, Universidad de Chile, Chile; ([4]) ESO, Chile; ([5]) Dipartimento di Fisica e Astronomia, Universitá di Padova, Italy

Previous studies of the Carina region have revealed its complexity and richness, and the presence of a significant number of early type stars. However, in many cases, these studies only concentrate on the central region (Trumpler 14/16), or are not homogeneous. This latter aspect, in particular, is crucial, since very different ages and distances for key clusters have been claimed for in recent years. The aim of this work is to study in detail an area of the Galactic plane in Carina, eastward Eta Carina. We analyze the properties of different stellar populations focusing our attention on a sample of open clusters, and their population of YSOs and highly reddened early stars. We also aim at studying the stellar mass distribution in these clusters and the possible scenario of their formation. Finally, we attempt at outlining the Galactic spiral structure in this direction. We obtained deep and homogeneous photometric data UBVI for six young open clusters: NGC 3752, Trumpler 18, NGC 3590, Hogg 10, 11, and 12, located in Carina at l $\sim 291^{\circ}$, and their adjacent stellar fields, that we complemented with spectroscopic observations of a few selected targets. We also culled additional information from the literature, which includes stellar spectral classifications and near infrared photometry from 2MASS. We finally developed a numerical code that allowed to perform a homogeneous and systematic analysis of the data. Our results provide more reliable estimates of distances, color excesses, masses, and ages of the stellar populations in this direction. We estimated the basic parameters of the studied clusters and found that they identify two over-densities of young stellar populations located at about 1.8 kpc and 2.8 kpc, with E_{B-V} 0.1–0.6. We found evidence of pre-main sequence populations inside them, with an apparent coeval stellar formation in the case of the most conspicuous clusters. We also discussed an apparent age and distance gradients in the direction NW-SE. We studied the mass distributions of the covered clusters and several other ones in the region (that we take form the literature), and which consistently showed a canonical IMF slope (the Salpeter one). We discovered and characterised an abnormally reddened massive stellar population, scattered between 6.6 and 11 kpc. Spectroscopic observations of ten stars of this latter population showed that all selected targets were massive OB stars. Their location is consistent with the position of the Carina-Sagittarius spiral arm.

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https://arxiv.org/abs/1606.01958

Galactic Globular Clusters

MOCCA-SURVEY database I. Accreting white dwarf binary systems in globular clusters – I. cataclysmic variables – present-day population

D. Belloni [1,2], M. Giersz [1], A. Askar [1], N. Leigh [3], and A. Hypki [4]

([1]) Nicolaus Copernicus Astronomical Centre, Polish Academy of Sciences, Warsaw, Poland; ([2]) CAPES Foundation, Ministry of Education of Brazil, Brasilia, Brazil; ([3]) Department of Astrophysics, American Museum of Natural History, New York, USA; ([4]) Leiden Observatory, Leiden University, Leiden, the Netherlands

In this paper, which is the first in a series of papers associated with cataclysmic variables and related objects, we introduce the CATUABA code, a numerical machinery written for analysis of the MOCCA simulations, and show some first results by investigating the present-day population of cataclysmic variables in globular clusters. Emphasis was given on their properties and the observational selection effects when observing and detecting them. In this work we analysed in this work six models, including three with Kroupa distributions of the initial binaries. We found that for models with Kroupa initial distributions, considering the standard value of the efficiency of the common envelope phase adopted in BSE, no single cataclysmic variable was formed only via binary stellar evolution, i. e., in order to form them, strong dynamical interactions have to take place. We show and explain why this is inconsistent with observational and theoretical results. Our results indicate that the population of cataclysmic variables in globular clusters is, mainly, in the last stage of their evolution and observational selection effects can drastically change the expected number of observed cataclysmic variables. We show that the probability of observing them during the outbursts is extremely small and conclude that the best way of looking for cataclysmic variables in globular clusters is by searching for variabilities during quiescence, instead of during outbursts. For that, one would need a very deep observation which could reach magnitudes $\gtrsim$ 27 mag. Finally, we argue that cataclysmic variables in globular clusters are not necessarily magnetic.

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Near-infrared photometry and spectroscopy of the low Galactic latitude globular cluster 2MASS-GC 03

J. Carballo-Bello [1,2], S. Ramírez Alegrá [1,2], J. Borissova [1,2], and 12 co-authors

([1]) Instituto de Física y Astronomía, Facultad de Ciencias, Universidad de Valparaíso, Chile; ([2]) Millennium Institute of Astrophysics, Santiago, Chile

We present deep near-infrared photometry and spectroscopy of the globular cluster 2MASS-GC03 projected in the Galactic disk using MMIRS on the Clay telescope (Las Campanas Observatory) and VISTA Variables in the Vía Láctea survey (VVV) data. Most probable cluster member candidates were identified from near-infrared photometry. Out of ten candidates that were followed-up spectroscopically, five have properties of cluster members, from which we calculate [Fe/H] $= -0.9 \pm 0.2$ and a radial velocity of $v_r = -78 \pm 12$ km s^{-1}. A distance of 10.8 kpc is estimated from 3 likely RRLyrae members. Given that the cluster is currently at a distance of 4.2 kpc from the Galactic center, the cluster's long survival time of an estimated 11.3±1.2Gyr strengthens the case for its globular-cluster nature. The cluster has a hint of elongation in the direction of the Galactic center.

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`https://arxiv.org/abs/1607.05286`

An AO-assisted variability study of four globular clusters

R. Salinas [1], R. Contreras Ramos [2], J. Strader [3], and 4 co-authors

([1]) Gemini Observatory, La Serena, Chile; ([2]) Instituto de Astrofísica, Pontificia Universidad Cat'olica de Chile, Macul, Chile; ([3]) Department of Physics and Astronomy, Michigan State University, East Lansing, USA

The image subtraction technique applied to study variable stars in globular clusters represented a leap in the number of new detections, with the drawback that many of these new light curves could not be transformed to magnitudes due to the severe crowding. In this paper we present observations of four Galactic globular clusters, M 2 (NGC 7089), M 10 (NGC 6254), M 80 (NGC 6093) and NGC 1261, taken with the ground-layer adaptive optics module at the SOAR Telescope, SAM. We show that the higher image quality provided by SAM allows the calibration of the light curves of the great majority of the variables near the cores of these clusters as well as the detection of new variables even in clusters where image-subtraction searches were already conducted. We report the discovery of 15 new variables in M 2 (12 RR Lyrae stars and 3 SX Phe stars), 12 new variables in M 10 (11 SX Phe and one long-period variable) and one new W UMa-type variable in NGC 1261. No new detections are found in M 80, but previous uncertain detections are confirmed and the corresponding light curves are calibrated into magnitudes. Additionally, based on the number of detected variables and new HST/UVIS photometry, we revisit a previous suggestion that M 80 may be the globular cluster with the richest population of blue stragglers in our Galaxy.

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`http://arxiv.org/abs/1605.06517`

Clusters in the Magellanic clouds

Star Clusters in the Magellanic Clouds-1: Parameterisation and Classification of 1072 Clusters in the LMC

P. K. Nayak [1], A. Subramaniam [1], S. Choudhury [1,2], G. Indu [1], and R. Sagar [1]

([1]) Indian Institute of Astrophysics, Bangalore, India; ([2]) Indian Institute of Science, Bangalore, India

We have introduced a semi-automated quantitative method to estimate the age and reddening of 1072 star clusters in the Large Magellanic Cloud (LMC) using the Optical Gravitational Lensing Experiment (OGLE) III survey data. This study brings out 308 newly parameterised clusters. In a first of its kind, the LMC clusters are classified into groups based on richness/mass as very poor, poor, moderate and rich clusters, similar to the classification scheme of open clusters in the Galaxy. A major cluster formation episode is found to happen at 12525 Myr in the inner LMC. The bar region of the LMC appears prominently in the age range 60 - 250 Myr and is found to have a relatively higher concentration of poor and moderate clusters. The eastern and the western ends of the bar are found to form clusters initially, which later propagates to the central part. We demonstrate that there is a significant difference in the distribution of clusters as a function of mass, using a movie based on the propagation (in space and time) of cluster formation in various groups. The importance of including the low mass clusters in the cluster formation history is demonstrated. The catalog with parameters, classification, and cleaned and isochrone fitted CMDs of 1072 clusters, which are available as online material, can be further used to understand the hierarchical formation of clusters in selected regions of the LMC.

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First Observational Signature of Rotational Deceleration in a Massive, Intermediate-age Star Cluster in the Magellanic Clouds

X. Wu [1,2], C. Li [2,3,4], R. de Grijs [2,5], and L. Deng [3]

([1]) School of Physics, Peking University, China; ([2]) Kavli Institute for Astronomy & Astrophysics and Department of Astronomy, Peking University, China; ([3]) Key Laboratory for Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, China; ([4]) Department of Physics and Astronomy, Macquarie University, Sydney, Australia; ([5]) International Space Science Institute–Beijing, China

While the extended main-sequence turn-offs (eMSTOs) found in almost all 1–2 Gyr-old star clusters in the Magellanic Clouds are often explained by postulating extended star-formation histories, the tight subgiant branches (SGBs) seen in some clusters challenge this popular scenario. Puzzlingly, the SGB of the eMSTO cluster NGC 419 is significantly broader at bluer than at redder colors. We carefully assess and confirm the reality of this observational trend. If we would assume that the widths of the features in color–magnitude space were entirely owing to a range in stellar ages, the star-formation histories of the eMSTO stars and the blue SGB region would be significantly more prolonged than that of the red part of the SGB. This cannot be explained by assuming an internal age spread. We show that rotational deceleration of a population of rapidly rotating stars, a currently hotly debated alternative scenario, naturally explains the observed trend along the SGB. Our analysis shows that a 'converging' SGB could be produced if the cluster is mostly composed of rapidly rotating stars that slow down over time owing to the conservation of angular momentum during their evolutionary expansion from main-sequence turn-off stars to red giants.

Accepted by : The Astrophysical Journal Letters
`http://arxiv.org/abs/1607.0491`

The most distant clusters

Panchromatic Hubble Andromeda Treasury XVI. Star Cluster Formation Efficiency and the Clustered Fraction of Young Stars

L. C. Johnson [1,2], A. C. Seth [3], J. J. Dalcanton [2], and 10 co-authors

([1]) Center for Astrophysics and Space Sciences, University of California, USA; ([2]) Department of Astronomy, University of Washington, USA; ([3]) Department of Physics and Astronomy, University of Utah, USA

We use the Panchromatic Hubble Andromeda Treasury (PHAT) survey dataset to perform spatially resolved measurements of star cluster formation efficiency (Γ), the fraction of stellar mass formed in long-lived star clusters. We use robust star formation history and cluster parameter constraints, obtained through color-magnitude diagram analysis of resolved stellar populations, to study Andromeda's cluster and field populations over the last $\sim$300 Myr. We measure Γ of 4–8% for young, 10–100 Myr old populations in M31. We find that cluster formation efficiency varies systematically across the M31 disk, consistent with variations in mid-plane pressure. These Γ measurements expand the range of well-studied galactic environments, providing precise constraints in an Hi-dominated, low intensity star formation environment. Spatially resolved results from M31 are broadly consistent with previous trends observed on galaxy-integrated scales, where Γ increases with increasing star formation rate surface density ($\Sigma_{\rm SFR}$). However, we can explain observed scatter in the relation and attain better agreement between observations and theoretical models if we account for environmental variations in gas depletion time ($\tau_{\rm dep}$) when modeling Γ, accounting for the qualitative shift in star formation behavior when transitioning from a H_2-dominated to a HI-dominated interstellar medium. We also demonstrate that Γ measurements in high $\Sigma_{\rm SFR}$ starburst systems are well-explained by $\tau_{\rm dep}$-dependent Γ modeling.

Accepted by : Astrophysical Journal
http://arxiv.org/abs/1606.05349

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Infrared High-Resolution Integrated Light Spectral Analyses of M31 Globular Clusters from APOGEE

C. M. Sakari [1], M. D. Shetrone [2], R. P. Schiavon [3,4], and 10 co-authors

([1]) Department of Astronomy, University of Washington, USA; ([2]) McDonald Observatory, University of Texas at Austin, USA; ([3]) Gemini Observatory, USA; ([4]) Astrophysics Research Institute, Liverpool John Moores University, UK

Chemical abundances are presented for 25 M31 globular clusters (GCs), based on moderately high resolution (R = 22 500) H-band integrated light spectra from the Apache Point Observatory Galactic Evolution Experiment (APOGEE). Infrared spectra offer lines from new elements, of different strengths, and at higher excitation potentials compared to the optical. Integrated abundances of C, N, and O are derived from CO, CN, and OH molecular features, while Fe, Na, Mg, Al, Si, K, Ca, and Ti abundances are derived from atomic features. These abundances are compared to previous results from the optical, demonstrating the validity and value of infrared integrated light analyses. The CNO abundances are consistent with typical tip of the red giant branch stellar abundances, but are systematically offset from optical, Lick index abundances. With a few exceptions, the other abundances agree between the optical and the infrared within the 1σ uncertainties. The first integrated K abundances are also presented, and demonstrate that K tracks the alpha-elements. The combination of infrared and optical abundances allows better determinations of GC properties, and enables probes of the multiple populations in extragalactic GCs. In particular, the integrated effects of the Na/O anticorrelation can be directly examined for the first time.

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http://arxiv.org/abs/1607.06811

Dynamical evolution - Simulations

Isotopic enrichment of forming planetary systems from supernova pollution

T. Lichtenberg [1,2], R. J. Parker [3], and M. R. Meyer [2]

([1]) Institute of Geophysics, ETH Zurich, Zurich, Switzerland; ([2]) Institute for Astronomy, ETH Zurich, Zurich, Switzerland; ([3]) Astrophysics Research Institute, Liverpool John Moores University, Liverpool, UK

Heating by short-lived radioisotopes (SLRs) such as aluminum-26 and iron-60 fundamentally shaped the thermal history and interior structure of Solar System planetesimals during the early stages of planetary formation. The subsequent thermo-mechanical evolution, such as internal differentiation or rapid volatile degassing, yields important implications for the final structure, composition and evolution of terrestrial planets. SLR-driven heating in the Solar System is sensitive to the absolute abundance and homogeneity of SLRs within the protoplanetary disk present during the condensation of the first solids. In order to explain the diverse compositions found for extrasolar planets, it is important to understand the distribution of SLRs in active planet formation regions (star clusters) during their first few Myr of evolution. By constraining the range of possible effects, we show how the imprint of SLRs can be extrapolated to exoplanetary systems and derive statistical predictions for the distribution of aluminum-26 and iron-60 based on N-body simulations of typical to large clusters (1000-10000 stars) with a range of initial conditions. We quantify the pollution of protoplanetary disks by supernova ejecta and show that the likelihood of enrichment levels similar to or higher than the Solar System can vary considerably, depending on the cluster morphology. Furthermore, many enriched systems show an excess in radiogenic heating compared to Solar System levels, which implies that the formation and evolution of planetesimals could vary significantly depending on the birth environment of their host stars.

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Do open star clusters evolve toward energy equipartition?

M. Spera [1], M. Mapelli [1], and R. D. Jeffries [2]

([1]) INAF, Osservatorio Astronomico di Padova, Padova, Italy; ([2]) Astrophysics Group, Keele University, Keele, UK

We investigate whether open clusters (OCs) tend to energy equipartition, by means of direct N-body simulations with a broken power-law mass function. We find that the simulated OCs become strongly mass segregated, but the local velocity dispersion does not depend on the stellar mass for most of the mass range: the curve of the velocity dispersion as a function of mass is nearly flat even after several half-mass relaxation times, regardless of the adopted stellar evolution recipes and Galactic tidal field model. This result holds both if we start from virialized King models and if we use clumpy sub-virial initial conditions. The velocity dispersion of the most massive stars and stellar remnants tends to be higher than the velocity dispersion of the lighter stars. This trend is particularly evident in simulations without stellar evolution. We interpret this result as a consequence of the strong mass segregation, which leads to Spitzer's instability. Stellar winds delay the onset of the instability. Our simulations strongly support the result that OCs do not attain equipartition, for a wide range of initial conditions.

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Kinematical evolution of tidally limited star clusters: the role of retrograde stellar orbits

M. Tiongco [1], E. Vesperini [1], and A. L. Varri [2]

([1]) Department of Astronomy, Indiana University, USA; ([2]) Institute for Astronomy, University of Edinburgh, UK

The presence of an external tidal field often induces significant dynamical evolutionary effects on the internal kinematics of star clusters. Previous studies investigating the restricted three-body problem with applications to star cluster dynamics have shown that unbound stars on retrograde orbits (with respect to the direction of the cluster's orbit) are more stable against escape than prograde orbits, and predicted that a star cluster might acquire retrograde rotation through preferential escape of stars on prograde orbits. In this study we present evidence of this prediction, but we also illustrate that there are additional effects that cannot be accounted for by the preferential escape of prograde orbits alone. Specifically, in the early evolution, initially underfilling models increase their fraction of retrograde stars without losing significant mass, and acquire a retrograde angular velocity. We attribute this effect to the development of preferentially eccentric/radial orbits in the outer regions of star clusters as they are expanding into their tidal limitation. We explore the implications of the evolution of the fraction of prograde and retrograde stars for the evolution of the cluster internal rotation, and its dependence on the initial structural properties. Although all the systems studied here evolve towards an approximately solid-body internal rotation with angular velocity equal to about half of the angular velocity of the cluster orbital motion around the host galaxy, the evolutionary history of the radial profile of the cluster internal angular velocity depends on the cluster initial structure.

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`http://arxiv.org/abs/1606.06743`

Miscellaneous

The Gaia-ESO Survey: Revisiting the Li-rich giant problem

A. R. Casey [1], G. Ruchti [2], T. Masseron [1], and 48 co-authors

([1]) Institute of Astronomy, University of Cambridge, Cambridge, UK; ([2]) Lund Observatory, Department of Astronomy and Theoretical Physics, Lund, Sweden

The discovery of lithium-rich giants contradicts expectations from canonical stellar evolution. Here we report on the serendipitous discovery of 20 Li-rich giants observed during the Gaia-ESO Survey, which includes the first nine Li-rich giant stars known towards the CoRoT fields. Most of our Li-rich giants have near-solar metallicities, and stellar parameters consistent with being before the luminosity bump. This is difficult to reconcile with deep mixing models proposed to explain lithium enrichment, because these models can only operate at later evolutionary stages: at or past the luminosity bump. In an effort to shed light on the Li-rich phenomenon, we highlight recent evidence of the tidal destruction of close-in hot Jupiters at the sub-giant phase. We note that when coupled with models of planet accretion, the observed destruction of hot Jupiters actually predicts the existence of Li-rich giant stars, and suggests Li-rich stars should be found early on the giant branch and occur more frequently with increasing metallicity. A comprehensive review of all known Li-rich giant stars reveals that this scenario is consistent with the data. However more evolved or metal-poor stars are less likely to host close-in giant planets, implying that their Li-rich origin requires an alternative explanation, likely related to mixing scenarios rather than external phenomena.

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`http://adsabs.harvard.edu/abs/2016MNRAS.461.3336C`

Testing Modified Gravity with Dwarf Spheroidal Galaxies

H. Haghi and V. Amiri
Institute for Advanced Studies in Basic Sciences (IASBS), Zanjan, Iran

The observed velocity dispersion of the classical dwarf spheroidal (dSph) galaxies of the Milky Way (MW) requires the Newtonian stellar mass-to-light (M_*/L) ratios in the range of about 10 to more than 100 solar units, that are well outside the acceptable limit predicted by stellar population synthesis (SPS) models. Using Jeans analysis, we calculate the line-of-sight velocity dispersion (σ_{los}) of stars in eight MW dSphs in the context of the Modified Gravity (MOG) theory of Moffat, assuming a constant M_*/L ratio without invoking the exotic cold dark matter. First, we use the weak field approximation of MOG and assume the two parameters α and μ of the theory to be constant as has already been inferred from fitting to the observed rotational data of the THINGS catalog of galaxies. We find that the derived M_*/L ratios for almost all dSphs are too large to be explained by the stellar population values. In order to fit the line-of-sight velocity dispersions of the dSph with reasonable M_*/L values we must vary α and μ on a case by case basis. A common pair of values cannot be found for all dSphs. Comparing with the values found from rotation curve fitting, it appears that μ correlates strongly with galaxy luminosity, shedding doubt on it as a universal constant.

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OGLE Study of the Sagittarius Dwarf Spheroidal Galaxy and its M54 Globular Cluster

A. Hamanowicz [1], P. Pietrukowicz [1], A. Udalski [1], and 9 co-authors
([1]) Warsaw University Observatory, Poland

We use the fundamental-mode RR Lyr-type variable stars (RRab) from OGLE-IV survey to draw a 3D picture of the central part of the tidally disrupted Sagittarius Dwarf Spheroidal (Sgr dSph) galaxy. We estimate the line-of-sight thickness of the Sgr dSph stream to be $\mathrm{FWHM_{cen}}$=2.42 kpc. Based on OGLE-IV observations collected in seasons 2011–2014 we conduct a comprehensive study of stellar variability in the field of the globular cluster M54 (NGC 6715) residing in the core of this dwarf galaxy. Among the total number of 268 detected variable stars we report the identification of 174 RR Lyr stars, four Type II Cepheids, 51 semi-regular variable red giants, three SX Phe-type stars, 18 eclipsing binary systems. Eighty-three variable stars are new discoveries. The distance to the cluster determined from RRab stars is $\mathrm{d_{M54}} = 26.7 \pm 0.03_{\mathrm{stat}} \pm 1.3_{\mathrm{sys}}$ kpc. From the location of RRab stars in the period-amplitude (Bailey) diagram we confirm the presence of two old populations, both in the cluster and the Sgr dSph stream.

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`http://adsabs.harvard.edu/abs/2016AcA....66..197H`

Ph.D. (dissertation) summaries

X-ray Populations in The Local Group: Insights with *Hubble* and *Chandra*

N. Vulic
Department of Physics & Astronomy, University of Western Ontario, London, ON, Canada

X-ray observations provide a unique perspective on the most energetic processes in the Universe. In particular, Low-mass X-ray binaries (LMXBs) found in globular clusters have been shown to depend on the mass, radius, and metallicity of the cluster. This thesis focuses on the impact environmental parameters have on X-ray sources and the underlying physical explanations for them. I studied the X-ray binary population in M31 using 1 Ms of *Chandra* ACIS data and 6-filter photometry from the Panchromatic *Hubble* Andromeda Treasury Survey. From a sample of 83 star clusters we found the brightest and most compact star clusters preferentially hosted an X-ray source. An investigation of 1566 H II regions found that neither radius nor Hα luminosity was a predictor of an H II region hosting an X-ray source. To study the faintest X-ray sources a stacking analysis of star clusters and H II regions was completed. Non-detections throughout resulted in upper limits of $\approx 10^{32}$ erg s^{-1}. I produced the most sensitive *Chandra* X-ray point source catalogue of M31, detecting 795 X-ray sources in an area of ≈ 0.6 deg^2, to a limiting unabsorbed $0.5 - 8.0$ keV luminosity of $\sim 10^{34}$ erg s^{-1}. The flatter completeness-corrected X-ray luminosity function of the bulge compared to the disk, consistent with previous work, indicated a lack of bright high-mass X-ray binaries in the disk and an aging population of LMXBs in the bulge. I also investigated the origin of the relationship between the metallicity of 109 Galactic globular clusters and LMXB formation by studying the number density of red giant branch (RGB) stars. A Spearman Rank test between the RGB star density and metallicity [Fe/H] confirmed the data could not have been drawn from a random distribution.

PhD thesis completed June 30th, 2016 at The University of Western Ontario under the supervision of Prof. Pauline Barmby and Prof. S. C. Gallagher.
The thesis is available at: `http://ir.lib.uwo.ca/etd/3802/`

Conferences

MODEST-16 NYC: A Conference on Gas and Gravitational Dynamics

6–9 September, 2016
New York City, USA
www.amnh.org/our-research/physical-sciences/astrophysics/events/modest-16-nyc

late registration, contact the organizers

Stellar aggregates over mass and spatial scales 631. Wilhelm und Else Heraeus-Seminar

5–9 December, 2016
Bad Honnef, Germany
https://astro.uni-bonn.de/conferences/aggregates2016/index.html

registration and abstract submission closes at 30$^{\text{th}}$ Sept. 2016

Frontiers in Theoretical and Applied Physics (with sessions on Stellar Clusters)

22–25 February, 2017
Sharjah/Dubai, United Arab Emirates
http://www.aus.edu/info/200227/conferences/586/ftaps_2017/1

abstract submission closes at 15$^{\text{th}}$ Nov. 2016

Conference Summaries

Multiple Populations in Globular Clusters: Where do we stand?

Haus Sexten - Via Dolomiti 45, 39030, Sexten, Italy
25.07.2016 - 29.07.2016

C. Lardo [1], N. Bastian [1], S. S. Larsen [2], A. Mucciarelli [3], and E. Pancino [4,5]
([1]) Astrophysics Research Institute, Liverpool John Moores University, Liverpool, UK; ([2]) Department of Astrophysics / IMAPP, Radboud University, Nijmegen, the Netherlands; ([3]) Department of Physics and Astronomy, University of Bologna, Bologna, Italy; ([4]) INAF-Osservatorio Astrofisico di Arcetri, Firenze, Italy; ([5]) ASI Science Data Center, Roma, Italy.

In the past two decades, our understanding of globular clusters (GCs) and their formation has undergone a radical change, replenishing cluster research with new discoveries and new questions. It is now widely recognised that GCs host multiple stellar populations with variations in the abundances of He, light elements (C, N, O, F, K, Na, Mg, Al, Si), and even heavy-elements in a few cases. High precision colour-magnitude diagram of GCs have also found that nearly all GCs display complex and unexpected features, with splits and/or spreads in the main sequences, red-giant branches, etc. A number of (qualitative) theories have been put forward to explain the observed anomalies, but a predictive scenario to explain their multiple populations is still missing. Indeed, the origin of multiple population is still disputed and many question remain unanswered.

Recent high-resolution observations with the HST have revealed that GCs, once thought only be able to form in the special conditions present in the early Universe, are still forming today. Those young massive clusters (YMCs) have been found in a variety of galactic environments characterised by strong star formation activity. They can be considered as young counterparts to the ancient GCs, as their sizes, masses, and luminosities are entirely consistent with what is expected for young GCs in the Milky Way. Do YMCs show evidence for multiple generations of stars? Can they be used to constrain theories for the origin of the multiple populations observed in GCs?

The origin of multiple populations within GCs is arguably the most active research field within the GC community at the present, with more than 350 published papers in the last 5 years. Despite the recent advances from the modelling side, theory is still far behind observations and is unlikely that most of the questions on GC formation and evolution will be answered without a new insight. The main goals of the workshop was to generate fresh perspectives and unexplored avenues of study by bringing together theorists and observers that were focussed on a two related (YMCs and GCs) fields of study.

The workshop, held in Sexten (IT), was meant as a continuation of our previous workshops on stellar clusters in 2012 and 2014 (*The formation and Early evolution of Stellar Clusters*, Sexten, July 23$^{\rm rd}$-27$^{\rm th}$, 2012 and *A critical Look at Globular Cluster Formation Theories: Constraints from Young Massive Cluster*, Sexten, July 14$^{\rm th}$-18$^{\rm th}$, 2014) and complimented the 2016 workshop on *The Role of Feedback in the Formation and Evolution of Star Clusters*, Sexten, July 18$^{\rm th}$-22$^{\rm nd}$ 2016.

The invited and contributed talks given during this workshop were designed to cover the state-of-the-art data on multiple population formation from both the observational and theoretical side. A selection of the main scientific highlights of the meeting can be summarised as follows:

1. Exciting new results and fresh insights are expected from the *UV Legacy Survey of Galactic Globular Clusters* data, which will be released soon to the community. A detailed analysis of this large photometric database demonstrated that a strong correlation between cluster mass and spreads in He content among GC stars exists, along with a correlation between mass and fraction of enriched stars-to-starts with primordial composition. Both trends are not easily explained within any of the proposed scenarios for the formation of MPs, but they represent crucial observables to make progress in our understanding of this topic.

2. Nearly all old GCs, with ages ≥10 Gyr, in the Milky Way and in external galaxies do show MPs. Conversely, no evidence for MPs has been found in young clusters with ages ≤ 2 Gyr, which additionally show no evidence for extended star formation and are gas free from very early stages; at odds with the expectations from the scenarios proposed to explain the origin of MPS. However, new exciting results presented during our workshop demonstrated that photometric and spectroscopic MPs can be found also in clusters with ages ∼6-8 Gyr. This means that the process responsible for MPs must operate until at least a redshift of z∼0.65.

3. Also mass may play a role. It appears that NGC 6535, an old GC with a mass of $\sim 1.5 \times 10^4 M_{\odot}$, hosts MPs, despite its low mass.

4. For a few GCs, also an intrinsic iron spread has been measured. This finding implies that GCs showing internal Fe dispersion were much more massive at their birth, possibly being the nuclei of dwarfs disrupted by Milky Way tidal fields, as supernovae ejecta are too energetic to be retained by $\sim 10^5$ $M_{\odot}$ systems like Galactic GCs. The two most notable cases are ω Centauri and Terzan 5, which display an ∼1 dex large, multimodal iron dispersion. Smaller intrinsic iron variations have been reported in a number of GCs, but the observational evidence is still conflicting. New modelling efforts should be devoted to this topic in order to assess whether the observed star-to-star variations are genuine iron dispersions or not, as the satellite hypothesis would have a great impact on our understanding of the hierarchal formation of structure in the ancient Universe.

5. Do we need an entirely new paradigm to explain these populations other than the stellar nucleosynthesis proposed so far? An updated AGB scenario that can account for a number of observational properties has been discussed during the workshop, along with a preliminary version of a model which is aimed at alleviate (or solve) the mass budget problem. Updated super-massive star models have also been presented.

6. New opportunities (and challenges) will come from the vast amount of data coming from the ground-based large surveys (4MOST, WEAVE,GALAH,APOGEE, Gaia-ESO) and space missions (HST, Kepler, K2, Gaia).

7. How can we explain the discovery of a new class of bulge nitrogen-rich stars from APOGEE data? Are those stars formed in GCs that have been disrupted? Or do they represent a new insight, suggesting that GCs are not necessary to form MPs.

8. It appears that the extended main sequences observed in young and intermediate age clusters are not due to actual age spreads, but instead are caused by stellar rotation. Stellar rotation also appears to cause multiple discrete main sequences in YMCs. Direct measurements of the rotation rates of stars in YMCs is now required to make progress on this.

`https://sites.google.com/site/sextenmpgc2016/home`
`http://www.sexten-cfa.eu/en/conferences/2016/details/`
`74-6-multiple-populations-in-stellar-clusters-where-do-we-stand.html`

Star Clusters: From Infancy to Teenagehood

Max-Planck Haus, Heidelberg, Germany
08.08.2016 - 12.08.2016

G. Parmentier
Astronomisches Rechen-Institut, Zentrum für Astronomie, Heidelberg, Germany

About 80 participants attended the conference, which took place at the Max-Planck Haus in Heidelberg, Germany, the week of 8 – 12 August 2016. The conference was divided into three sessions:

(1) Star Clusters in the Making
(2) Multiple Stellar Populations in Clusters, and
(3) Cluster Dissolution.

The 50 talks and 20 posters provided an overview and new details, both observational and theoretical, on numerous topics of star cluster research.

The conference started with an emphasis on the star-forming molecular gas, its complex structure made of filaments, clumps and cores, and the turbulence pervading it. Finding and characterizing forming clusters, the stellar and substellar initial mass functions, and our current understanding of star formation relations constituted the other milestones of the first session. Additionally, star-cluster formation and evolution in extragalactic environments also received some attention.

In the second session, the spectroscopic and photometric evidence for multiple stellar populations in globular clusters was reviewed, followed by a description of the models aimed at accounting for their differences in chemistry, structure and kinematics. The characteristics needed for a cluster to host multiple stellar populations were also discussed.

The third session, cluster dissolution and its contribution to the field star population, proved a lively topic, too. How the cluster initial conditions inherited from the formation process affect the cluster longer-term evolution was discussed. They included the primordial mass-segregation, the equipartition of stellar systems, the respective spatial distributions of stars and gas, and the degree of cluster tidal filling, to name but a few.

The program was completed by two lively discussion sessions, led by Tom Megeath (Toledo, USA) and Franca d'Antona (Rome, Italy), respectively, as well as by relaxing social events. Finally, Elena Sabbi (Baltimore, USA) provided an excellent conference summary.

That the conference covered topics as distinct as giant molecular clouds and the multiple stellar populations of old globular clusters, has helped researchers from different fields meet each other, which has been praised by many participants.

`http://wwwstaff.ari.uni-heidelberg.de/infant_clusters_2016/`