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

IAU
The official Newsletter of
the IAU Commission H4.

SCYON Issue No. 65 August 27^{th}, 2015

Dear colleagues,

A few months ago Prof. Janusz Kaluzny, a well-known Polish astronomer, passed away at age of 60. Many of us do remember him very well. He worked with star clusters for many many years, publishing almost 300 papers on the subject. With this brief editorial we invite the star cluster community to remember him and his fundamental work on old open clusters, variable stars in globular clusters (he was the head of the CASE - Cluster AgeS Experiment - project), and OGLE. He was an enthusiastic, tireless astronomer, and a friend to many of us. You can read more about that here: *https://www.camk.edu.pl/en/archiwum/2015/03/07/zmarl-prof-janusz-kaluzny/* .

The Editors

The remaining space of this editorial is dedicated to a more pleasant topic, and we allocate this space to Richard de Grijs, the president of the new IAU star cluster commission:

. . . . . .

Dear colleagues,

Since the previous SCYON Newsletter, many developments have occurred in the star cluster field. At the time of writing, the International Astronomical Union's General Assembly (IAU GA) has just been concluded; it featured a highly successful Symposium on the "Formation, Evolution, and Survival of Massive Star Clusters", capably chaired by Corinne Charbonnel and Antonella Nota. Kudos to them for pulling off a wonderful meeting!

The IAU GA was also a pivotal time for the future of star cluster research. During the preceding triennium, the IAU underwent significant changes, ultimately leading to the abolishment of all of its scientific Commissions. As lead proposer of a small but dedicated team of scientists keenly interested in star cluster physics, I am very pleased to announce that establishment of a new (and hopefully improved) Commission on "Star Clusters Throughout Cosmic Time and Space" was approved by the IAU's Executive Committee. Commission H4 has attracted a strong team of highly qualified Organizing Committee members from around the world. As your new President, I will be working with Vice President Amanda Karakas (Australia), as well as with Francesca DAntona (Italy), André Moitinho (Portugal), Jan Palouš (Czech Republic), Ernst Paunzen (Czech Republic), and Alison Sills (Canada).

The new Commission will of course continue along similar lines as those set out by its previous Presidents, Bruce Elmegreen (2009–2012) and Giovanni Carraro (2012–2015), but we have many new ideas as well, so watch this space! Indeed, together with the SCYON editorial team, we intend to transform SCYON into a newsletter that serves both the Commission H4 membership and its much larger and more diverse scientific audience. I look forward to coordinating the new Commission and working with you all to make our field as exciting and productive as we can!

Richard de Grijs
(President, IAU Commission H4)

CONTENTS

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

Tracing the Galactic spiral structure with embedded clusters

D. Camargo [1,2], C. Bonatto [1], and E. Bica [1]

([1]) Departamento de Astronomia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil; ([2]) Colégio Militar de Porto Alegre, Ministério da Defesa - Exército Brasileiro, Porto Alegre, Brazil

In this work, we investigate the properties of 18 embedded clusters (ECs). The sample includes 11 previously known clusters and we report the discovery of seven ECs on WISE images, thus complementing our recent list of 437 new clusters. The main goal is to use such clusters to shed new light on the Galactic structure by tracing the spiral arms with cluster distances. Our results favour a four-armed spiral pattern tracing three arms, Sagitarius-Carina, Perseus, and the Outer arm. The Sagitarius-Carina spiral arm is probed in the borderline of the third and fourth quadrants at a distance from the Galactic Centre of $d_1 \sim 6.4$ kpc adopting $R_\odot = 7.2$ kpc, or $d_2 \sim 7.2$ kpc for $R_\odot = 8.0$ kpc. Most ECs in our sample are located in the Perseus arm that is traced in the second and third quadrants and appear to be at Galactocentric distances in the range $d_1 = 9$–10.5 kpc or $d_2 = 9.8$–11.3 kpc. Dolidze 25, Bochum 2, and Camargo 445 are located in the Outer arm that extends along the second and third Galactic quadrants with a distance from the Galactic Centre in the range of $d_1 = 12.5$–14.5 kpc or $d_2 = 13.5$–15.5 kpc. We find further evidence that in the Galaxy ECs are predominantly located within the thin disc and along spiral arms. They are excellent tools for tracing these Galactic features and therefore new searches for ECs can contribute to a better understanding of the Galactic structure. We also report an EC aggregate located in key italicthe Perseus arm.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://www.jpl.nasa.gov/news/news.php?feature=4612`

IN-SYNC III: The dynamical state of IC 348 - A super-virial velocity dispersion and a puzzling sign of convergence

M. Cottaar [1], K. R. Covey [2,3], J. B. Foster [4], and 11 co-authors

([1]) Institute for Astronomy, ETH Zurich, Zurich, Switzerland; ([2]) Lowell Observatory, Flagstaff, USA; ([3]) Department of Physics and Astronomy, Western Washington University, Bellingham, USA; ([4]) Yale Center for Astronomy and Astrophysics, Yale University New Haven, USA

Most field stars will have encountered the highest stellar density and hence the largest number of interactions in their birth environment. Yet the stellar dynamics during this crucial phase are poorly understood. Here we analyze the radial velocities measured for 152 out of 380 observed stars in the 2-6 Myr old star cluster IC 348 as part of the SDSS-III APOGEE. The radial velocity distribution of these stars is fitted with one or two Gaussians, convolved with the measurement uncertainties including binary orbital motions. Including a second Gaussian improves the fit; the high-velocity outliers that are best fit by this second component may either (1) be contaminants from the nearby Perseus OB2 association, (2) be a halo of ejected or dispersing stars from IC 348, or (3) reflect that IC 348 has not relaxed to a Gaussian velocity distribution. We measure a velocity dispersion for IC 348 of 0.72 ± 0.07 $\mathrm{km\,s^{-1}}$ (or 0.64 ± 0.08 $\mathrm{km\,s^{-1}}$ if two Gaussians are fitted), which implies a supervirial state, unless the gas contributes more to the gravitational potential than expected. No evidence is found for a dependence of this velocity dispersion on distance from the cluster center or stellar mass. We also find that stars with lower extinction (in the front of the cloud) tend to be redshifted compared with stars with somewhat higher extinction (towards the back of the cloud). This data suggests that the stars in IC 348 are converging along the line of sight. We show that this correlation between radial velocity and extinction is unlikely to be spuriously caused by the small cluster rotation of 0.024 ± 0.013 $\mathrm{km\,s^{-1}\ arcmin^{-1}}$ or by correlations between the radial velocities of neighboring stars. This signature, if confirmed, will be the first detection of line-of-sight convergence in a star cluster. Possible scenarios for reconciling this convergence with IC 348's observed supervirial state include: a) the cluster is fluctuating around a new virial equilibrium after a recent disruption due to gas expulsion or a merger event, or b) the population we identify as IC 348 results from the chance alignment of two sub-clusters converging along the line of sight. Additional measurements of tangential and radial velocities in IC 348 will be important for clarifying the dynamics of this region, and informing models of the formation and evolution of star clusters. The radial velocities analyzed in this paper have been made available online.

Accepted by : Astrophysical Journal
`http://arxiv.org/abs/1505.07504`

Galactic Open Clusters

A comprehensive study of the open cluster NGC 6866

Z. F. Bostanci [1], T. Ak [1], T. Yontan [2], and 15 co-authors

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

We present CCD UBVRI photometry of the field of the open cluster NGC 6866. Structural parameters of the cluster are determined utilizing the stellar density profile of the stars in the field. We calculate the probabilities of the stars being a physical member of the cluster using their astrometric data and perform further analyses using only the most probable members. The reddening and metallicity of the cluster were determined by independent methods. The LAMOST spectra and the ultraviolet excess of the F and G type main-sequence stars in the cluster indicate that the metallicity of the cluster is about the solar value. We estimated the reddening $E(B-V) = 0.074 \pm 0.050$ mag using the $(U-B)$ vs $(B-V)$ two-colour diagram. The distance modula, the distance and the age of NGC 6866 were derived as 10.60±0.10 mag, 1189±75 pc and 813±50 Myr, respectively, by fitting colour-magnitude diagrams of the cluster with the PARSEC isochrones. The Galactic orbit of NGC 6866 indicates that the cluster is orbiting in a slightly eccentric orbit with $e = 0.12$. The mass function slope $x = 1.35 \pm 0.08$ was derived by using the most probable members of the cluster.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://arxiv.org/abs/1507.05968

.....

Binary open clusters in the Milky Way: photometric and spectroscopic analysis of NGC 5617 and Trumpler 22

G. M. De Silva [1], G. Carraro [2], V. D'Orazi [3], and 4 co-authors

([1]) Australian Astronomical Observatory, NSW 2113, Australia; ([2]) European Southern Observatory, Santiago, Chile; ([3]) INAF - Osservatorio Astronomico di Padova, Padova, Italy

Using photometry and high-resolution spectroscopy we investigate for the first time the physical connection between the open clusters NGC 5617 and Trumpler 22. Based on new CCD photometry we report their spatial proximity and common age of ∼70 Myr. Based on high-resolution spectra collected using the HERMES and UCLES spectrographs on the Anglo-Australian telescope, we present radial velocities and abundances for Fe, Na, Mg, Al, Si, Ca, and Ni. The measured radial velocities are -38.63 ± 2.25 km s^{-1} for NGC 5617 and -38.46 ± 2.08 km s^{-1} for Trumpler 22. The mean metallicity of NGC 5617 was found to be [Fe/H] $= -0.18 \pm 0.02$ and for Trumpler 22 was found to be [Fe/H] $= -0.17 \pm 0.04$. The two clusters share similar abundances across the other elements, indicative of a common chemical enrichment history of these clusters. Together with common motions and ages we confirm that NGC 5617 and Trumpler 22 are a primordial binary cluster pair in the Milky Way.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://arxiv.org/abs/1507.03230

The Gaia-ESO Survey: Insights into the inner-disc evolution from open clusters

L. Magrini [1], S. Randich [1], P. Donati [2], and 37 co-authors

([1]) INAF-Osservatorio Astrofisico di Arcetri, Firenze, Italy; ([2]) INAF-Osservatorio Astronomico di Bologna, Italy

The inner disc, which links the thin disc with the bulge, has been somewhat neglected in the past because of the intrinsic difficulties in its study, among which crowding and high extinction. Open clusters located in the inner disc are among thebest tracers of its chemistry at different ages and distances. We analyse the chemical patterns of four open clusters located within 7 kpc of the Galactic centre and of field stars to infer the properties of the inner disc with the Gaia-ESO survey idr2/3 data release. We derive the parameters of the newly observed cluster, Berkeley 81, finding an age of about 1 Gyr and a Galactocentric distance of ∼5.4 kpc. We construct the chemical patterns of clusters and we compare them with those of field stars in the solar neighbourhood and in the inner-disc samples. Comparing the three populations we observe that inner-disc clusters and field stars are both, on average, enhanced in [O/Fe], [Mg/Fe], and [Si/Fe]. Using the idr2/3 results of M67, we estimate the non-local thermodynamic equilibrium (NLTE) effect on the abundances of Mg and Si in giant stars. After empirically correcting for NLTE effects, we note that NGC 6705 and Be 81 still have a high [α/Fe]. The location of the four open clusters and of the field population reveals that the evolution of the metallicity [Fe/H] and of [α/Fe] can be explained within the framework of a simple chemical evolution model: both [Fe/H] and [α/Fe] of Trumpler 20 and of NGC 4815 are in agreement with expectations from a simple chemical evolution model. On the other hand, NGC 6705, and to a lesser degree Berkeley 81, have higher [α/Fe] than expected for their ages, location in the disc, and metallicity. These differences might originate from local enrichment processes as explained in the inhomogeneous evolution framework.

Accepted by : Astronomy & Astrophysics

`http://adsabs.harvard.edu/abs/2015A%26A...580A..85M`

.....

A comparative study on the reliability of open cluster parameters

M. Netopil [1], E. Paunzen [1], and G. Carraro [2]

([1]) UTFA, Masaryk University, Brno, Czech Republic; ([2]) European Southern Observatory, Santiago, Chile

Open clusters are known as excellent tracers of the structure and chemical evolution of the Galactic disk, however, the accuracy and reliability of open cluster parameters is poorly known. In recent years, several studies aimed to present homogeneous open cluster parameter compilations, which are based on some different approaches and photometric data. These catalogues are excellent sources to facilitate testing of the actual accuracy of open cluster parameters. We compare seven cluster parameter compilations statistically and with an external sample, which comprises the mean results of individual studies. Furthermore, we selected the objects IC 4651, NGC 2158, NGC 2383, NGC 2489, NGC 2627, NGC 6603, and Trumpler 14, with the main aim to highlight differences in the fitting solutions. We derived correction terms for each cluster parameter, using the external calibration sample. Most results by the compilations are reasonable scaled, but there are trends or constant offsets of different degree. We also identified one data set, which appears too erroneous to allow adjustments. After the correction, the mean intrinsic errors amount to about 0.2 dex for the age, 0.08 mag for the reddening, and 0.35 mag for the distance modulus. However, there is no study that characterises the cluster morphologies of all test cases in a correct and consistent manner. Furthermore, we found that the largest compilations probably include at least 20 percent of problematic objects, for which the parameters differ significantly. These could be among others doubtful or unlikely open clusters.

Accepted by : Astronomy & Astrophysics

`http://arxiv.org/abs/1508.01296`

Search for variables in the open cluster King 12

E. Paunzen [1], M. Netopil [1], M. Rode-Paunzen [2], and H. Božić [3]

([1]) UTFA, Masaryk University, Brno, Czech Republic; ([2]) Institut für Astrophysik der Universität Wien, Vienna, Austria; ([3]) Hvar Observatory, Faculty of Geodesy, University of Zagreb, Zagreb, Croatia

We present the time series analysis of CCD photometry from the 1 m telescope at the Hvar Observatory (Croatia) for 54 stars in the area of the young open clusters King 12. We found no new variable but list upper detection limits.

Accepted by : Information Bulletin on Variable Stars
http://adsabs.harvard.edu/abs/2015IBVS.6144....1P

.....

Global survey of star clusters in the Milky Way IV. 63 new open clusters detected by proper motions

R.-D. Scholz [1], N.V. Kharchenko [2,3], A.E. Piskunov [2,4], S. Röser [2], and E. Schilbach [2,5]

([1]) Leibniz-Institut f. Astrophysik Potsdam, Potsdam, Germany; ([2]) Astronomisches Rechen-Institut, Zentrum f. Astronomie Univ. Heidelberg, Heidelberg, Germany; ([3]) Main Astronomical Observatory, Kiev, Ukraine ([4]) Institute of Astronomy of Russian Acad. Sci., Moscow, Russia; ([5]) Max-Planck-Institut f. Astronomie, Heidelberg, Germany

In their 1st extension to the Milky Way Star Clusters (MWSC) survey, Schmeja et al. applied photometric filters to the 2MASS to find new cluster candidates that were subsequently confirmed or rejected by the MWSC pipeline. To further extend the MWSC census, we aimed at discovering new clusters by conducting an almost global search in proper motion catalogues as a starting point. We first selected high-quality samples from the PPMXL and UCAC4 for comparison and verification of the proper motions. For 441 circular proper motion bins (radius 15 mas/yr) within ±50 mas/yr, the sky outside a thin Galactic plane zone (|b| <5°) was binned in small areas ('sky pixels') of 0.25×0.25 deg^2. Sky pixels with enhanced numbers of stars with a certain common proper motion in both catalogues were considered as cluster candidates. After visual inspection of the sky images, we built an automated procedure that combined these representations of the sky for neighbouring proper motion subsamples after a background correction. About half of our 692 candidates overlapped with known clusters (46 globular and 68 open clusters in the Galaxy, about 150 known clusters of galaxies) or the Magellanic Clouds. About 10% of our candidates turned out to be 63 new open clusters confirmed by the MWSC pipeline. They occupy predominantly the two inner Galactic quadrants and have apparent sizes and numbers of high-probable members slightly larger than those of the typically small MWSC clusters, whereas their other parameters (ages, distances, tidal radii) fall in the typical ranges. As our search aimed at finding compact clusters, we did not find new very nearby (extended) clusters. (abridged)

Accepted by : Astronomy & Astrophysics
http://arxiv.org/abs/1507.02125

Galactic Globular Clusters

Globular cluster mass-loss in the context of multiple populations

N. Bastian and C. Lardo
Astrophysics Research Institute, Liverpool John Moores University, Liverpool, UK

Many scenarios for the origin of the chemical anomalies observed in globular clusters (GCs; i.e. multiple populations) require that GCs were much more massive at birth, up to 10-100 times, than they are presently. This is invoked in order to have enough material processed through first generation stars in order to form the observed numbers of enriched stars (inferred to be second generation stars in these models). If such mass-loss was due to tidal stripping, gas expulsion, or tidal interaction with the birth environment, there should be clear correlations between the fraction of enriched stars and other cluster properties, whereas the observations show a remarkably uniform enriched fraction of 0.68 $\pm$ 0.07 (from 33 observed GCs). If interpreted in the heavy mass-loss paradigm, this means that all GCs lost the same fraction of their initial mass (between 95 and 98 per cent), regardless of their mass, metallicity, location at birth or subsequent migration, or epoch of formation. This is incompatible with predictions, hence we suggest that GCs were not significantly more massive at birth, and that the fraction of enriched to primordial stars observed in clusters today likely reflects their initial value. If true, this would rule out self-enrichment through nucleosynthesis as a viable solution to the multiple population phenomenon.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://adsabs.harvard.edu/abs/2015MNRAS.453..357B`

.....

NGC 6139: a normal massive globular cluster or a first-generation dominated cluster? Clues from the light elements

A. Bragaglia, E. Carretta, A. Sollima, and 5 co-authors
INAF-Osservatorio Astronomico di Bologna, Bologna, Italy

Information on globular clusters (GC) formation mechanisms can be gathered by studying the chemical signature of the multiple populations that compose these stellar systems. In particular, we are investigating the anticorrelations among O, Na, Al, and Mg to explore the influence of cluster mass and environment on GCs in the Milky Way and in extragalactic systems. We present here the results obtained on NGC 6139 which, on the basis of its horizontal branch morphology, had been proposed to be dominated by first-generation stars. In our extensive study based on high resolution spectroscopy, the first for this cluster, we found a metallicity of [Fe/H]= $-1.579 \pm 0.015 \pm 0.058$ (rms=0.040 dex, 45 bona fide member stars) on the UVES scale defined by our group. The stars in NGC 6139 show a chemical pattern normal for GCs, with a rather extended Na-O (and Mg-Al) anticorrelation. NGC 6139 behaves like expected from its mass and contains a large fraction (about two thirds) of second-generation stars.

Accepted by : Astronomy & Astrophysics
`http://arxiv.org/abs/1507.07562`

Five groups of red giants with distinct chemical composition in the globular cluster NGC 2808

E. Carretta
INAF-Osservatorio Astronomico di Bologna, Bologna, Italy

The chemical composition of multiple populations in the massive globular cluster (GC) NGC 2808 is addressed with the homogeneous abundance re-analysis of 140 red giant branch (RGB) stars. UVES spectra for 31 stars and GIRAFFE spectra for the other giants were analysed with the same procedures used for about 2500 giants in 23 GCs in our FLAMES survey, deriving abundances of Fe, O, Na, Mg, Si, Ca, Ti, Sc, Cr, Mn, and Ni. Iron, elements from alpha-capture, and in the Fe-group do not show intrinsic scatter. On our UVES scale the metallicity of NGC 2808 is [Fe/H]=−1.129 ±0.005 ±0.034 (± statistical ± systematic error) with σ=0.030 (31 stars). Main features related to proton-capture elements are retrieved, but the improved statistics and the smaller associated internal errors allow to uncover five distinct groups of stars along the Na-O anticorrelation. We observe large depletions in Mg, anticorrelated with enhancements of Na and also Si, suggestive of unusually high temperatures for proton-captures. About 14% of our sample is formed by giants with solar or subsolar [Mg/Fe] ratios. Using the [Na/Mg] ratios we confirm the presence of five populations with different chemical composition, that we called P1, P2, I1, I2, and E in order of decreasing Mg and increasing Na abundances. Statistical tests show that the mean ratios in any pair of groups cannot be extracted from the same parent distribution. The overlap with the five populations recently detected from UV photometry is good but not perfect, confirming that more distinct components probably exist in this complex GC.

Accepted by : Astrophysical Journal
`http://adsabs.harvard.edu/abs/2015arXiv150707553C`

The most distant clusters

Sizes and shapes of young star cluster light profiles in M83

J. E. Ryon [1], N. Bastian [2], A. Adamo [3], and 6 co-authors

([1]) Department of Astronomy, University of Wisconsin-Madison, USA; ([2]) Astrophysics Research Institute, Liverpool John Moores University, UK; ([3]) The Oskar Klein Centre, Department of Astronomy, Stockholm University, Sweden

We measure the radii and two-dimensional light profiles of a large sample of young, massive star clusters in M83 using archival HST/Wide Field Camera 3 (WFC3) imaging of seven adjacent fields. We use GALFIT to fit the two-dimensional light profiles of the clusters, from which we find effective (half-light) radii, core radii, and slopes of the power-law (EFF) profile (η). We find lognormal distributions of effective radius and core radius, with medians of ≈2.5 pc and ≈1.3 pc, respectively. Our results provide strong evidence for a characteristic size of young, massive clusters. The average effective radius and core radius increase somewhat with cluster age. Little to no change in effective radius is observed with increasing galactocentric distance, except perhaps for clusters younger than 100 Myr. We find a shallow correlation between effective radius and mass for the full cluster sample, but a stronger correlation is present for clusters 200-300 Myr in age. Finally, the majority of the clusters are best fit by an EFF model with index $\eta \lesssim 3.0$. There is no strong evidence for change in η with cluster age, mass, or galactocentric distance. Our results suggest that clusters emerge from early evolution with similar radii and are not strongly affected by the tidal field of M83. Mass-loss due to stellar evolution and/or GMC interactions appear to dominate cluster expansion in the age range we study.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://mnras.oxfordjournals.org/content/452/1/525`

.....

Optical-NIR analysis of globular clusters in the IKN dwarf spheroidal: a complex star formation history

A. Tudorica [1], I. Y. Georgiev [2], and A. L. Chies-Santos [3,4]

([1]) Argelander Institut für Astronomie der Universität Bonn, Bonn, Germany; ([2]) Max-Plank-Institut für Astronomie, Heidelberg, Germany; ([3]) Departamento de Astronomia, Instituto de Física, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil; ([4]) Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, São Paulo, Brazil

Age, metallicity and spatial distribution of globular clusters (GCs) provide a powerful tool to reconstruct major star-formation episodes in galaxies. IKN is a faint dwarf spheroidal (dSph) in the M81 group of galaxies. It contains five old GCs, which makes it the galaxy with the highest known specific frequency (SN=126). We estimate the photometric age, metallicity and spatial distribution of the poorly studied IKN GCs. We search SDSS for GC candidates beyond the HST field of view, which covers half of IKN. To break the age-metallicity degeneracy in the V-I colour we use WHT/LIRIS Ks-band photometry and derive photometric ages and metallicities by comparison with SSP models in the V,I,Ks colour space. IKN GCs' VIKs colours are consistent with old ages (≥ 8 Gyr) and a metallicity distribution with a higher mean than typical for such a dSph ([Fe/H] $\simeq -1.4^{+0.6}_{-0.2}$ dex). Their photometric masses range ($0.5 < M_{GC} < 4{\times}10^5$ $M_\odot$) implies a high mass ratio between GCs and field stars, of 10.6%. Mixture model analysis of the RGB field stars' metallicity suggests that 72% of the stars may have formed together with the GCs. Using the most massive GC-SFR relation we calculate a SFR of $\sim 10 M_\odot$/yr during its formation epoch. We note that the more massive GCs are closer to the galaxy photometric centre. IKN GCs also appear spatially aligned along a line close to the IKN major-axis and nearly orthogonal to the plane of spatial distribution of galaxies in the M81

group. We identify one new IKN GC candidate based on colour and PSF analysis of the SDSS data. The evidence towards i) broad and high metallicity distribution of the field IKN RGB stars and its GCs, ii) high fraction and iii), spatial alignment of IKN GCs, supports a scenario for tidally triggered complex IKN's SFH in the context of interactions with galaxies in the M81 group.

Accepted by : Astronomy & Astrophysics
http://arxiv.org/abs/1506.04155

. . . . . .

Dynamical evolution - Simulations

The dynamical evolution of low-mass hydrogen-burning stars, brown dwarfs and planetary-mass objects formed through disc fragmentation

Y. Li [1,2], M.B.N. Kouwenhoven [2,1], D. Stamatellos [3], and S.P. Goodwin [4]

([1]) Department of Astronomy, School of Physics, Peking University, Beijing, China; ([2]) Kavli Institute for Astronomy and Astrophysics, Peking University, Beijing, China ([3]) Jeremiah Horrocks Institute for Mathematics, Physics & Astronomy, University of Central Lancashire, Preston, UK; ([4]) Department of Physics & Astronomy, The University of Sheffield, Sheffield, UK

Theory and simulations suggest that it is possible to form low-mass hydrogen-burning stars, brown dwarfs and planetary-mass objects via disc fragmentation. As disc fragmentation results in the formation of several bodies at comparable distances to the host star, their orbits are generally unstable. Here, we study the dynamical evolution of these objects. We set up the initial conditions based on the outcomes of the SPH simulations of Stamatellos & Whitworth (2009), and for comparison we also study the evolution of systems resulting from lower-mass fragmenting discs. We refer to these two sets of simulations as set 1 and set 2. At 10 Myr, approximately half of the host stars have one companion left, and approximately 22% (set 1) to 9.8% (set 2) of the host stars are single. Systems with multiple secondaries in relatively stable configurations are common (about 30% and 44%, respectively). The majority of the companions are ejected within 1 Myr with velocities mostly below 5 km/s, with some runaway escapers with velocities over 30 km/s. About 6% (set 1) and 2% (set 2) of the companions pair up into very low-mass binary systems. The majority of these pairs escape as very low-mass binaries, while others remain bound to the host star in hierarchical configurations (often with retrograde inner orbits). Physical collisions with the host star (0.43 and 0.18 events per host star for set 1 and set 2) and between companions (0.08 and 0.04 events per host star for set 1 and set 2) are relatively common and their frequency increases with increasing disc mass. Our study predicts observable properties of very low-mass binaries, low-mass hierarchical systems, the brown dwarf desert, and free-floating brown dwarfs and planetary-mass objects in and near young stellar groupings, which can be used to distinguish between different formation scenarios of very low-mass stars, brown dwarfs and planetary-mass objects.

Accepted by : Astrophysical Journal
http://arxiv.org/abs/1506.03185

Dynamical Constraints on the Origin of Multiple Stellar Populations in Globular Clusters

P. Khalaj and H. Baumgardt
School of Mathematics and Physics, University of Queensland, St. Lucia, Australia

We have carried out a large grid of N-body simulations in order to investigate if mass-loss as a result of primordial gas expulsion can be responsible for the large fraction of second generation stars in globular clusters (GCs) with multiple stellar populations (MSPs). Our clusters start with two stellar populations in which 10% of all stars are second generation stars. We simulate clusters with different initial masses, different ratios of the half-mass radius of first to second generation stars, different primordial gas fractions and Galactic tidal fields with varying strength. We then let our clusters undergo primordial gas-loss and obtain their final properties such as mass, half-mass radius and the fraction of second generation stars. Using our N-body grid we then perform a Monte Carlo analysis to constrain the initial masses, radii and required gas expulsion time-scales of GCs with MSPs. Our results can explain the present-day properties of GCs only if (1) a substantial amount of gas was present in the clusters after the formation of second generation stars and (2) gas expulsion time-scales were extremely short ($\lesssim 10^5$ yr). Such short gas expulsion time-scales are in agreement with recent predictions that dark remnants have ejected the primordial gas from globular clusters, and pose a potential problem for the AGB scenario. In addition, our results predict a strong anti-correlation between the number ratio of second-generation stars in GCs and the present-day mass of GCs. So far, the observational data show only a significantly weaker anti-correlation, if any at all.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://arxiv.org/abs/1506.05303`

.....

Block Time Step Storage Scheme for Astrophysical N-body Simulations

M. Cai [1,2], Y. Meiron [2,1], M.B.N. Kouwenhoven [2], P. Assmann [3,1], and R. Spurzem [1,2]
([1]) NAO, Chinese Academy of Sciences, Beijing, China; ([2]) Kavli Institute for Astronomy and Astrophysics, Peking University, Beijing, China; ([3]) Universidad de Chile, Santiago, Chile;

Astrophysical research in recent decades has made significant progress thanks to the availability of various N-body simulation techniques. With the rapid development of high-performance computing technologies, modern simulations have been able to take the computing power of massively parallel clusters with more than 10^5 GPU cores. While unprecedented accuracy and dynamical scales have been achieved, the enormous amount of data being generated continuously poses great challenges for the subsequent procedures of data analysis and archiving. As an urgent response to these challenges, in this paper we propose an adaptive storage scheme for simulation data, inspired by the block time step integration scheme found in a number of direct N-body integrators available nowadays. The proposed scheme, namely the block time step storage scheme, works by minimizing the data redundancy with assignments of data with individual output frequencies as required by the researcher. As demonstrated by benchmarks, the proposed scheme is applicable to a wide variety of simulations. Despite the main focus of developing a solution for direct N-body simulation data, the methodology is transferable for grid-based or tree-based simulations where hierarchical time stepping is used.

Accepted by : Astrophysical Journal Supplement Series
`http://arxiv.org/abs/1506.07591`

M-dwarf binaries as tracers of star and brown dwarf formation

M. Marks [1,2], M. Janson [3], P. Kroupa [1], N. Leigh [4,5], and I. Thies [1]

([1]) Helmholtz-Institut für Strahlen- und Kernphysik, University of Bonn, Germany; ([2]) Clara-Fey-Gymnasium, Bonn, Germany; ([3]) Department of Astronomy, Stockholm University, Sweden ([4]) Department of Astrophysics, American Museum of Natural History, New York, USA; ([5]) Department of Physics, University of Alberta, Edmonton, Canada

The separation distribution for M-dwarf binaries in the ASTRALUX survey is narrower and peaking at smaller separations than the distribution for solar-type binaries. This is often interpreted to mean that M-dwarfs constitute a continuous transition from brown dwarfs (BDs) to stars. Here a prediction for the M-dwarf separation distribution is presented, using a dynamical population synthesis (DPS) model in which "star-like" binaries with late-type primaries ($\lesssim$1.5M$_\odot$) follow universal initial distribution functions and are dynamically processed in their birth embedded clusters. A separate "BD-like" population has both its own distribution functions for binaries and initial mass function (IMF), which overlaps in mass with the IMF for stars. Combining these two formation modes results in a peak on top of a wider separation distribution for late M-dwarfs consistent with the late ASTRALUX sample. The DPS separation distribution for early M-dwarfs shows no such peak and is in agreement with the M-dwarfs in Multiples (MinMS) data. We note that the latter survey is potentially in tension with the early ASTRALUX data. Concluding, the ASTRALUX and MinMS data are unable to unambiguously distinguish whether or not BDs are a continuous extension of the stellar IMF. Future observational efforts are needed to fully answer this interesting question. The DPS model predicts that binaries outside the sensitivity range of the ASTRALUX survey remain to be detected. For application to future data, we present a means to observationally measure the overlap of the putative BD-like branch and the stellar branch. We discuss the meaning of universal star formation and distribution functions.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://arxiv.org/abs/1506.05113`

.....

The dynamical fate of planetary systems in young star clusters

X. Zheng [1,2], M.B.N. Kouwenhoven [1], and L. Wang [1,2]

([1]) Kavli Institute for Astronomy and Astrophysics, Peking University, Beijing, China; ([2]) Department of Astronomy, Peking University, Beijing, China

We carry out N-body simulations to examine the effects of dynamical interactions on planetary systems in young open star clusters. We explore how the planetary populations in these star clusters evolve, and how this evolution depends on the initial amount of substructure, the virial ratio, the cluster mass and density, and the initial semi-major axis of the planetary systems. The fraction of planetary systems that remains intact as a cluster member, f_{BPS}, is generally well-described by the functional form $f_{BPS}=f_0(1+[a/a_0]^c)^{-1}$, where $(1-f_0)$ is the fraction of stars that escapes from the cluster, a_0 the critical semi-major axis for survival, and c a measure for the width of the transition region. The effect of the initial amount of substructure over time can be quantified as $f_{BPS}=A(t)+B(D)$, where A(t) decreases nearly linearly with time, and B(D) decreases when the clusters are initially more substructured. Provided that the orbital separation of planetary systems is smaller than the critical value a_0, those in clusters with a higher initial stellar density (but identical mass) have a larger probability of escaping the cluster intact. These results help us to obtain a better understanding of the difference between the observed fractions of exoplanets-hosting stars in star clusters and in the Galactic field. It also allows us to make predictions about the free-floating planet population over time in different stellar environments.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://arxiv.org/abs/1508.01593`

The Relative and Absolute Ages of Old Globular Clusters in the LCDM Framework

M. Trenti [1], P. Padoan [2], and R. Jimenez [2,3]

([1]) School of Physics, The University of Melbourne, Australia; ([2]) ICREA & ICC, University of Barcelona, Barcelona, Spain; ([3]) Institute for Applied Computational Science, Harvard University, USA

Old Globular Clusters (GCs) in the Milky Way have ages of about 13 Gyr, placing their formation time in the reionization epoch. We propose a novel scenario for the formation of these systems based on the merger of two or more atomic cooling halos at high-redshift (z>6). First generation stars are formed as an intense burst in the center of a minihalo that grows above the threshold for hydrogen cooling (halo mass $M_h \sim 10^8$ $M_\odot$) by undergoing a major merger within its cooling timescale ($\sim$150 Myr). Subsequent minor mergers and sustained gas infall bring new supply of pristine gas at the halo center, creating conditions that can trigger new episodes of star formation. The dark-matter halo around the GC is then stripped during assembly of the host galaxy halo. Minihalo merging is efficient only in a short redshift window, set by the LCDM parameters, allowing us to make a strong prediction on the age distribution for old GCs. From cosmological simulations we derive an average merging redshift <z>=9 and narrow distribution Δz=2, implying average GC age $<t_{age}>$=13.0$\pm$0.2 Gyr including $\sim$0.2 Gyr of star formation delay. Qualitatively, our scenario reproduces other general old GC properties (characteristic masses and number of objects, metallicity versus galactocentric radius anticorrelation, radial distribution), but unlike age, these generally depend on details of baryonic physics. In addition to improved age measurements, direct validation of the model at z$\sim$10 may be within reach of ultradeep gravitationally lensed observations with the James Webb Space Telescope.

Accepted by : Astrophysical Journal
`http://adsabs.harvard.edu/abs/2015ApJ...808L..35T`

.....

A probability theory for non-equilibrium gravitational systems

J. Peñarrubia

Institute for Astronomy, University of Edinburgh, Royal Observatory, Edinburgh, UK

This paper uses dynamical invariants to describe the evolution of collisionless systems subject to time-dependent gravitational forces without resorting to maximum-entropy probabilities. We show that collisionless relaxation can be viewed as a special type of diffusion process in the integral-of-motion space. In time-varying potentials with a fixed spatial symmetry the diffusion coefficients are closely related to virial quantities, such as the specific moment of inertia, the virial factor and the mean kinetic and potential energy of microcanonical particle ensembles. The non-equilibrium distribution function (DF) is found by convolving the initial DF with the Green function that solves Einsteins equation for freely diffusing particles and yields a natural solution to the Fokker-Planck equations in the energy space. Our mathematical formalism can be generalized to potentials with a time-varying symmetry, where diffusion extends over multiple dimensions of the integral-of-motion space. The new probability theory is in many ways analogous to stochastic calculus, with two significant differences: (i) the equations of motion that govern the trajectories of particles are fully deterministic, and (ii) the diffusion coefficients can be derived self-consistently from microcanonical phase-space averages without relying on ergodicity assumptions. For illustration we follow the cold collapse of N-body models in a time-dependent logarithmic potential. Comparison between the analytical and numerical results shows excellent agreement in regions where the potential evolution does not depart too strongly from the adiabatic regime.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://adsabs.harvard.edu/abs/2015MNRAS.451.3537P`

Miscellaneous

A family of lowered isothermal models

M. Gieles and A. Zocchi
Department of Physics, University of Surrey, Guildford, UK

We present a family of self-consistent, spherical, lowered isothermal models, consisting of one or more mass components, with parameterised prescriptions for the energy truncation and for the amount of radially biased pressure anisotropy. The models are particularly suited to describe the phase-space density of stars in tidally limited, mass-segregated star clusters in all stages of their life-cycle. The models extend a family of isotropic, single-mass models by Gomez-Leyton and Velazquez, of which the well-known Woolley, King and Wilson (in the non-rotating and isotropic limit) models are members. We derive analytic expressions for the density and velocity dispersion components in terms of potential and radius, and introduce a fast model solver in PYTHON (LIMEPY), that can be used for data fitting or for generating discrete samples.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://arxiv.org/abs/1508.02120`

. . . . . .

Apparent Age Spreads in Clusters and the Role of Stellar Rotation

F. Niederhofer [1,2], C. Georgy [3], N. Bastian [4], and S. Ekström [5]
([1]) Excellence Cluster Origin and Structure of the Universe, Garching, Germany; ([2]) Universitäts-Sternwarte München, München, Germany; ([3]) Astrophysics group, EPSAM, Keele University, Lennard-Jones Labs, Keele, UK; ([4]) Astrophysics Research Institute, Liverpool John Moores University, Liverpool, UK; ([5]) Geneva Observatory, University of Geneva, Sauverny, Switzerland

We use the Geneva Syclist isochrone models that include the effects of stellar rotation to investigate the role that rotation has on the resulting colour-magnitude diagram (CMD) of young and intermediate age clusters. We find that if a distribution of rotation velocities exists within the clusters, rotating stars will remain on the main sequence (MS) for longer, appearing to be younger than non-rotating stars within the same cluster. This results in an extended main sequence turn-off (eMSTO) that appears at young ages (~ 30 Myr) and lasts beyond 1 Gyr. If this eMSTO is interpreted as an age spread, the resulting age spread is proportional to the age of the cluster, i.e. young clusters (< 100 Myr) appear to have small age spreads (10s of Myr) whereas older clusters (~ 1 Gyr) appear to have much large spreads, up to a few hundred Myr. We compare the predicted spreads for a sample of rotation rates to observations of young and intermediate age clusters, and find a strong correlation between the measured age spread and the age of the cluster, in good agreement with models of stellar rotation. This suggests that the age spreads reported in the literature may simply be the result of a distribution of stellar rotation velocities within clusters.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://arxiv.org/abs/1507.07561`

A new catalogue of Stroemgren-Crawford uvbybeta photometry

E. Paunzen
UTFA, Masaryk University, Brno, Czech Republic

The uvbybeta photometric system is widely used for the study of various Galactic and extragalactic objects. It measures the colour due to temperature differences, the Balmer discontinuity, and blanketing absorption due to metals. A new all-sky catalogue of all available uvbybeta measurements from the literature was generated. The data for the individual stars were cross-checked on the basis of the Tycho-2 catalogue. This catalogue includes very precise celestial coordinates, but is magnitude and spatial resolution limited. However, the loss of objects is only marginal and is compensated for by the gain of homogeneity. In total, 298 639 measurements of 60 668 stars were used to derive unweighted mean indices and their errors. Photoelectric and CCD observations were treated in the same way. The presented data set can be used for various applications such as new calibrations of astrophysical parameters, the standardization of new observations, and as additional information for ongoing and forthcoming all-sky surveys. The areas of many star clusters, star forming regions, and associations are covered by the catalogue.

Accepted by : Astronomy & Astrophysics
`http://adsabs.harvard.edu/abs/2015A%26A...580A..23P`

.....

Local associations and the barium puzzle

A. B. S. Reddy and D. L. Lambert
W.J. McDonald Observatory and Department of Astronomy, The University of Texas at Austin, USA

We have observed high-dispersion echelle spectra of main-sequence stars in five nearby young associations – Argus, Carina-Near, Hercules-Lyra, Orion and Subgroup B4 – and derived abundances for elements ranging from Na to Eu. These are the first chemical abundance measurements for two of the five associations, while the remaining three associations are analysed more extensively in our study. Our results support the presence of chemical homogeneity among association members with a typical star-to-star abundance scatter of about 0.06 dex or less over many elements. The five associations show logϵ(Li) consistent with their age and share a solar chemical composition for all elements with the exception of Ba. We find that all the heavy elements (Y, Zr, La, Ce, Nd, Sm and Eu) exhibit solar ratios, i.e., [X/Fe] $\simeq$ 0, while Ba is overabundant by about 0.2-0.3 dex. The origin of the overabundance of Ba is a puzzle. Within the formulation of the s-process, it is difficult to create a higher Ba abundance without a similar increase in the s-process contributions to other heavy elements (La-Sm). Given that Ba is represented by strong lines of Ba II and La-Sm are represented by rather weak ionized lines, the suggestion, as previously made by other studies, is that the Ba abundance may be systematically overestimated by standard methods of abundance analysis perhaps because the upper reaches of the stellar atmospheres are poorly represented by standard model atmospheres. A novel attempt to analyse the Ba I line at 5535 Å gives a solar Ba abundance for stars with effective temperatures hotter than about 5800 K but increasingly subsolar Ba abundances for cooler stars with apparent Ba deficiencies of 0.5 dex at 5100 K. This trend with temperature may signal a serious non-LTE effect on the Ba I line.

Accepted by : Monthly Notices of the Royal Astronomical Society
`http://arxiv.org/abs/1508.02815`

Details of a spatial structure and kinematics of Castor and Ursa Major streams

S. V. Vereshchagin and N. V. Chupina
[1] Institute of Astronomy of the Russian Academy of Sciences (INASAN), Moscow, Russia

According to various authors a list of the members of the Castor stream has compiled. Given the individual apex, multiplicity, observational errors and peculiarity it is carried out a revision of the membership probabilities for some stars. By the method of apexes diagram is determined apex of the Castor moving group. The parameters of the Castor and Ursa Major streams are compared. The position on apex diagram of two streams are differ by 225°. It means they are moving in almost opposite direction. In space stars of both moving groups are mixed, the Castor stream takes up space less than UMa and is located inside it. Results are useful to understanding of morphology of a disk in the Sun vicinity.

Submitted to : Baltic Astronomy

. . . . . .

Proceedings abstracts

Membership determination of Open Clusters with CLUSTERIX

T. Sezima [1], D. Galadí-Enríquez [2], E. Paunzen [1], and 3 co-authors
([1]) Masaryk University, Brno, Czech Republic; ([2]) Centro Astronómico Hispano Alemán CAHA, Almería, Spain

The web-based application Clusterix has been developed as a collaboration between the Masaryk University (Czech Republic) and the Universitat de Barcelona (Spain) to calculate the membership probability of open clusters on the WEBDA database using a completely non parametric method (Galadí-Enríquez et al., 1998; Balaguer-Núñez et al., 2004). WEBDA is a site devoted to observational data on stars in Galactic open clusters. Clusterix is an interactive tool where the user can define the default values to configure the membership estimation for the area of a cluster. Gaia's capabilities to study the kinematics of clusters of stars with great accuracy is one of the main motivations for the development of this tool. The applet first version can be found at: `http://clusterix.cerit-sc.cz/`

To appear in: Highlights of Spanish Astrophysics VIII, Proceedings of the XI Scientific Meeting of the Spanish Astronomical Society held on September 8-12, 2014, in Teruel, Spain
`http://adsabs.harvard.edu/abs/2015hsa8.conf..594S`

Books

Ecology of blue straggler stars

H. Boffin, G. Carraro, and G. Beccari
European Southern Observatory, Santiago, Chile

The existence of blue straggler stars (BSS), which appear younger, hotter, and more massive than their siblings, is at odds with a simple picture of stellar evolution, as such stars should have exhausted their nuclear fuel and evolved long ago to become cooling white dwarfs. As such, BSS could just be some quirks but in fact their understanding requires a deep knowledge of many different areas in astronomy, from stellar evolution through cluster dynamics, from chemical abundances to stellar populations. In November 2012, a workshop on this important topic took place at the ESO Chilean headquarters in Santiago. The many topics covered at this workshop were introduced by very comprehensive invited reviews, providing a unique and insightful view on the field. These reviews have now become chapters of the first ever book on BSS.

Book published by Springer
`http://www.springer.com/us/book/9783662444337`

.....

Pulsating Stars

M. Catelan [1,2] and H. A. Smith [3]
([1]) Pontificia Universidad Católica de Chile, Santiago, Chile; ([2]) Millennium Institute of Astrophysics, Santiago, Chile; ([3]) Michigan State University, East Lansing, MI, USA

This book surveys our understanding of stars which change in brightness because they pulsate. Pulsating variable stars are keys to distance scales inside and beyond the Milky Way galaxy. They test our understanding not only of stellar pulsation theory but also of stellar structure and evolution theory. Moreover, pulsating stars are important probes of the formation and evolution of our own and neighboring galaxies. Our understanding of pulsating stars has greatly increased in recent years as large-scale surveys of pulsating stars in the Milky Way and other Local Group galaxies have provided a wealth of new observations and as space-based instruments have studied particular pulsating stars in unprecedented detail.

Book published by Wiley-VCH
`http://adsabs.harvard.edu/abs/2015pust.book.....C`

Conferences

Feedback in the Magellanic Clouds

5-7 October, 2015
Baltimore, USA
http://www.stsci.edu/institute/conference/fimc/

Registration deadline: Aug. 31, 2015!!! (abstract submission already closed)

MODEST 15-S

7-11 December, 2015
Kobe, Japan
http://modest15s.net/

Late registration deadline: Nov. 7, 2015 / Abstracts and early registration deadline: Sept. 7, 2015