The Star Clusters Young & Old Newsletter

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Dear subscribers,

As many of you heard about, IAU is undergoing a major revolution. This initially involved restructuring at Division level. Old divisions disappeared before last General Assembly in Beijing in 2012, and new Divisions took place. It is now the turn of Commissions to evolve into more active and better representing entities. Many old Commissions were in fact stagnant. This process touches also the actual Commission 37 Star Clusters and Associations, which will disappear soon before the next General Assembly in Honolulu in 2015. The process of reinstating a commission on star clusters within Division H (Interstellar Matter and Local Universe) already started. A team of active and well recognised colleagues in the field, led by Richard de Grijs, already submitted a Letter of Intent to the IAU secretariat. The team is composed by Richard who will act as new commission president, Amanda Karakas, who will act as new commission vice-president, Sally Oey, and Giovanni Carraro (as actual commission president). The Letter of Intent focused on stressing how active is the field of star clusters, from their birth to their dissolution, and their role as tracers of galaxy structure and evolution. Besides, the letter also remarks the importance of this newsletter (SCYON) as an information driver. In the future commission, we would like SCYON to be a sort of official commission newsletter. A full proposal will then be submitted by 31 January, 2015.

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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

Testing the universality of the IMF with Bayesian statistics: young clusters

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The universality of the stellar initial mass function (IMF) is tested using Bayesian statistics with a sample of eight young Galactic stellar clusters (IC 348, ONC, NGC 2024, NGC 6611, NGC 2264, ρ Ophiuchi, Chameleon I, and Taurus). We infer the posterior probability distribution function (pPDF) of the IMF parameters when the likelihood function is described by a tapered power law function, a lognormal distribution at low masses coupled to a power law at higher masses, and a multi-component power law function. The inter-cluster comparison of the pPDFs of the IMF parameters for each likelihood function shows that these distributions do not overlap within the 1σ uncertainty level. Furthermore, the most probable values of the IMF parameters for most of the clusters deviate substantially from their values for the Galactic field stellar IMF. We also quantify the effects of taking into account the completeness correction as well as the uncertainties on the measured masses. The inclusion of the former affects the inferred pPDFs of the slope of the IMF at the low mass end while considering the latter affects the pPDFs of the slope of the IMF in the intermediate- to high mass regime. As variations are observed in all of the IMF parameters at once and for each of the considered likelihood functions, even for completeness corrected samples, we argue that the observed variations are real and significant, at least for the sample of eight clusters considered in this work. The results presented here clearly show that the IMF is not universal.

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NGC 7538 : Multiwavelength Study of Stellar Cluster Regions associated with IRS 13 and IRS 9 sources

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We present deep and high-resolution (FWHM $\sim 0.4''$) near-infrared (NIR) imaging observations of the NGC 7538 IRS 1–3 region (in JHK bands), and IRS 9 region (in HK bands) using the 8.2m Subaru telescope. The NIR analysis is complemented with GMRT low-frequency observations at 325, 610, and 1280 MHz, molecular line observations of $H^{13}CO^+$ (J=1–0), and archival Chandra X-ray observations. Using the 'J-H/H-K' diagram, 144 Class II and 24 Class I young stellar object (YSO) candidates are identified in the IRS 1–3 region. Further analysis using 'K/H-K' diagram yields 145 and 96 red sources in the IRS 1–3 and IRS 9 regions, respectively. A total of 27 sources are found to have X-ray counterparts. The YSO mass function (MF), constructed using a theoretical mass-luminosity relation, shows peaks at substellar ($\sim$0.08–0.18 $M_\odot$) and intermediate ($\sim$1–1.78 $M_\odot$) mass ranges for the IRS 1–3 region. The MF can be fitted by a power law in the low mass regime with a slope of $\Gamma \sim$ 0.54–0.75, which is much shallower than the Salpeter value of 1.35. An upper limit of 10.2 is obtained for the star to brown dwarf ratio in the IRS 1–3 region. GMRT maps show a compact HII region associated with the IRS 1–3 sources, whose spectral index of 0.87$\pm$0.11 suggests optical thickness.

This compact region is resolved into three separate peaks in higher resolution 1280 MHz map, and the 'East' sub-peak coincides with the IRS 2 source. $H^{13}CO^+$ (J=1–0) emission reveals peaks in both IRS 1–3 and IRS 9 regions, none of which are coincident with visible nebular emission, suggesting the presence of dense cloud nearby. The virial masses are approximately of the order of 1000 $M_\odot$ and 500 $M_\odot$ for the clumps in IRS 1–3 and IRS 9 regions, respectively.

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The orbital motion of the Quintuplet cluster - a common origin for the Arches and Quintuplet clusters?

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We investigate the orbital motion of the Quintuplet cluster near the Galactic center with the aim of constraining formation scenarios of young, massive star clusters in nuclear environments. Three epochs of adaptive optics high-angular resolution imaging with Keck/NIRC2 and VLT/NACO were obtained over a time baseline of 5.8 years, delivering an astrometric accuracy of 0.5–1 mas/yr. Proper motions were derived in the cluster reference frame and were used to distinguish cluster members from the majority of field stars. Fitting the cluster and field proper motion distributions with 2D gaussian models, we derive the orbital motion of the cluster for the first time. The Quintuplet is moving with a 2D velocity of 132 ± 15 km s^{-1} with respect to the field along the Galactic plane, which yields a 3D orbital velocity of 167 ± 15 km s^{-1} when combined with the previously known radial velocity. From a sample of 119 stars measured in three epochs, we derive an upper limit to the velocity dispersion in the core of the Quintuplet cluster of $\sigma_{1D} < 10$ km s^{-1}. Knowledge of the three velocity components of the Quintuplet allows us to model the cluster orbit in the potential of the inner Galaxy. Comparing the Quintuplet's orbit with the Arches orbit, we discuss the possibility that both clusters originated in the same area of the central molecular zone. [abridged]

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Galactic Open Clusters

A uvbyCaHbeta Analysis of the Old Open Cluster, NGC 6819

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NGC 6819 is a richly populated, older open cluster situated within the Kepler field. A CCD survey of the cluster on the uvbyCaHbeta system, coupled with proper-motion membership, has been used to isolate 382 highly probable, single-star unevolved main-sequence members over a 20-arcminute field centered on the cluster. From 278 F dwarfs with high precision photometry in all indices, a mean reddening of E(b-y) = 0.117 ± 0.005 or E(B-V) = 0.160 ± 0.007 is derived, where the standard errors of the mean include both internal errors and the photometric zero-point uncertainty. With the reddening fixed, the metallicity derived from the same 278 stars is [Fe/H] = −0.116 ± 0.101 from m_1 and −0.055 ± 0.033 from hk, for a weighted average of [Fe/H] = −0.06 ± 0.04, where the quoted standard errors of the mean values include the internal errors from the photometric scatter plus the uncertainty in the photometric zero points. If metallicity is derived using individual reddening values for each star to account for potential reddening variation across the face of the cluster, the analogous result is unchanged. The cluster members at the turnoff of the color-magnitude diagram are used to test and confirm the recently discovered variation in reddening across the face of the cluster, with a probable range in the variation of Delta[E(B-V)] = 0.045 ± 0.015. With the slightly higher reddening and lower [Fe/H] compared to commonly adopted values, isochrone fitting leads to an age of 2.3 ± 0.2 Gyr for an apparent modulus of (m-M) = 12.40 ± 0.12.

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Clues on the Galactic evolution of sulphur from star clusters

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The abundances of alpha-elements are a powerful diagnostic of the star formation history and chemical evolution of a galaxy. Sulphur, being moderately volatile, can be reliably measured in the interstellar medium (ISM) of damped Ly-alpha galaxies and extragalactic HII regions. Measurements in stars of different metallicity in our Galaxy can then be readily compared to the abundances in external galaxies. Such a comparison is not possible for Si or Ca that suffer depletion onto dust in the ISM. Furthermore, studying sulphur is interesting because it probes nucleosynthetic conditions that are very different from those of O or Mg. The measurements in star clusters are a reliable tracers of the Galactic evolution of sulphur. We find $<A(S)>_{NLTE}$=6.11±0.04 for M 4, $<A(S)>_{NLTE}$=7.17±0.02 for NGC 2477, and $<A(S)>_{NLTE}$=7.13±0.06 for NGC 5822. For the only star studied in Trumpler 5 we find $A(S)_{NLTE}$=6.43±0.03 and $A(S)_{LTE}$=6.94±0.05. Our measurements show that, by and large, the S abundances in Galactic clusters trace reliably those in field stars. The only possible exception is Trumpler 5, for which the NLTE sulphur abundance implies an [S/Fe] ratio lower by roughly 0.4 dex than observed in field stars of comparable metallicity, even though its LTE sulphur abundance is in line with abundances of field stars. Moreover the LTE sulphur abundance is consistent only with the abundance of another alpha-element, Mg, in the same star, while the low NLTE value is consistent with Si and Ca. The S abundances in our sample of stars in clusters imply that the clusters are chemically homogeneous for S within 0.05 dex.

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Abundance analysis of red clump stars in the old, inner disc, open cluster NGC 4337: a twin of NGC 752?

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Open star clusters older than ∼1 Gyr are rare in the inner Galactic disc. Still, they are objects that hold crucial information for probing the chemical evolution of these regions of the Milky Way. We aim at increasing the number of old open clusters in the inner disc for which high-resolution metal abundances are available. Here we report on NGC 4337, which was recently discovered to be an old, inner disc open cluster. We present the very first high-resolution spectroscopy of seven clump stars that are all cluster members. We performed a detailed abundance analysis for them. We find that NGC 4337 is marginally more metal-rich than the Sun, with [Fe/H]=+0.12±0.05. The abundance ratios of α-elements are generally solar. At odds with recent studies on intermediate-age and old open clusters in the Galactic disc, Ba is under-abundant in NGC 4337 compared with the Sun. Our analysis of the iron-peak elements (Cr and Ni) does not reveal anything anomalous. Based on these results, we estimate the cluster age to be 1.6±0.1 Gyr, and derive a reddening E(B-V)=0.23±0.05, and an apparent distance modulus $(m - M)_V$=12.80±0.15. Its distance to the Galactic centre is 7.6 kpc. With this distance and metallicity, NGC 4337 fits the metallicity gradient for the inner Galactic disc fairly well. The age and metallicity we measured make NGC 4337 a twin of the well-known old open cluster NGC 752. The red clumps of these two clusters bear an amazing resemblance. But the main sequence of NGC 752 is significantly more depleted in stars than that of NGC 4337. This would mean that NGC 752 is in a much more advanced dynamical stage, being on the verge of dissolving into the general Galactic field. Our results make NGC 4337 an extremely interesting object for further studies of stellar evolution in the critical turn-off mass range 1.1–1.4 solar masses.

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A probable pre-main sequence chemically peculiar star in the open cluster Stock 16

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We used the Ultraviolet and Visual Echelle Spectrograph of the ESO-Very Large Telescope to obtain a high resolution and high signal-to-noise ratio spectrum of Stock 16-12, an early-type star which previous Δa photometric observations suggest being a chemically peculiar (CP) star. We used spectral synthesis to perform a detailed abundance analysis obtaining an effective temperature of 8400 ± 400 K, a surface gravity of 4.1 ± 0.4, a microturbulence velocity of $3.4^{+0.7}_{-0.3}$ km s^{-1}, and a projected rotational velocity of 68 ± 4 km s^{-1}. We provide photometric and spectroscopic evidence showing the star is most likely a member of the young Stock 16 open cluster (age 3–8 Myr). The probable cluster membership, the star's position in the Hertzsprung-Russell diagram, and the found infrared excess strongly suggest the star is still in the pre-main-sequence (PMS) phase. We used PMS evolutionary tracks to determine the stellar mass, which ranges between 1.95 and 2.3 $M_\odot$, depending upon the adopted spectroscopic or photometric data results. Similarly, we obtained a stellar age ranging between 4 and 6 Myr, in agreement with that of the cluster. Because the star's chemical abundance pattern

resembles well that known of main sequence CP metallic line (Am) stars, the object sets important constraints to the diffusion theory. Additional spectroscopic and spectropolarimetric data allowed us to conclude that the object is probably a single non-magnetic star.

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Gemini spectroscopy of the outer disk star cluster BH176

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BH176 is an old metal-rich star cluster. It is spatially and kinematically consistent with belonging to the Monoceros Ring. It is larger in size and more distant from the Galactic plane than typical open clusters, and it does not belong to the Galactic bulge. Our aim is to determine the origin of this unique object by accurately determining its distance, metallicity, and age. The best way to reach this goal is to combine spectroscopic and photometric methods. We present medium-resolution observations of red clump and red giant branch stars in BH176 obtained with the Gemini South Multi-Object Spectrograph.We derive radial velocities, metallicities, effective temperatures, and surface gravities of the observed stars and use these parameters to distinguish member stars from field objects. We determine the following parameters for BH176: V_h=0±15 km s^{-1}, [Fe/H]=−0.1±0.1, age 7±0.5 Gyr, E(V−I)=0.79±0.03, distance 15.2±0.2 kpc, α-element abundance [α/Fe]∼0.25 dex (the mean of [Mg/Fe], and [Ca/Fe]). BH176 is a member of old Galactic open clusters that presumably belong to the thick disk. It may have originated as a massive star cluster after the encounter of the forming thin disk with a high-velocity gas cloud or as a satellite dwarf galaxy.

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Galactic Globular Clusters

The first Δa observations of three globular clusters

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Globular clusters are main astrophysical laboratories to test and modify evolutionary models. Thought to be rather homogeneous in their local elemental distribution of members, results suggest a wide variety of chemical peculiarities. Besides different main sequences, believed to be caused by different helium abundances, peculiarities of blue horizontal-branch stars and on the red giant branch were found. This whole zoo of peculiar objects has to be explained in the context of stellar formation and evolution. The tool of Δa photometry is employed in order to detect peculiar stars in the whole spectral range. This three filter narrow-band system measures the flux distribution in the region from 4900 to 5600 Å in order to find any peculiarities around 5200 Å. It is highly efficient to detect classical chemically peculiar stars of the upper main sequence, Be/Ae, shell and metal-weak objects in the Milky Way and Magellanic Clouds. We present Delta-a photometry of 2266 stars from 109 individual frames for three globular clusters (NGC 104, NGC 6205, and NGC 7099). A comparison with published abundances, for three horizontal-branch stars, only, yields an excellent agreement. According to the 3σ detection limit of each globular cluster, about 3 per cent of the stars lie in abnormal regions in the diagnostic diagrams. The first observations of three widely different aggregates give very promising results, which will serve as a solid basis for follow-up observations including photometric as well as spectroscopic studies.

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`http://mnras.oxfordjournals.org/content/443/3/2492.full`

Clusters in the Magellanic clouds

Constraining globular cluster formation through studies of young massive clusters - III. A lack of gas and dust in massive stellar clusters in the LMC and SMC

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Scenarios that invoke multiple episodes of star formation within young globular clusters (GCs) to explain the observed chemical and photometric anomalies in GCs, require that clusters can retain the stellar ejecta of the stars within them and accrete large amounts of gas from their surroundings. Hence, it should be possible to find young massive clusters in the local Universe that contain significant amounts ($> 10\%$) of the cluster mass of gas and/or dust within them. Recent theoretical studies have suggested that clusters in the Large Magellanic Cloud (LMC) with masses in excess of $10^4 M_\odot$, and ages between 30 and ~ 300 Myr, should contain such gas reservoirs. We have searched for HI gas within 12 LMC (and 1 SMC) clusters and also for dust using *Spitzer* 70μm and 160μm images. No clusters were found to contain gas and/or dust. While two of the clusters have HI at the same (projected) position and velocity, the gas does not appear to be centred on the clusters, but rather part of nearby clouds or filaments, suggesting that the gas and cluster are not directly related. This lack of gas ($< 1\%$ of the stellar mass) is in strong tension with model predictions, and may be due to higher stellar feedback than has been previously assumed or due to the assumptions used in the previous calculations.

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The most distant clusters

The AIMSS Project II: Dynamical-to-Stellar Mass Ratios Across the Star Cluster - Galaxy Divide

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The previously clear division between small galaxies and massive star clusters is now occupied by objects called ultra compact dwarfs (UCDs) and compact ellipticals (cEs). Here we combine a sample of UCDs and cEs with velocity dispersions from the AIMSS project with literature data to explore their dynamical-to-stellar mass ratios. We confirm that the mass ratios of many UCDs in the stellar mass range 10^6 – 10^9 $M_\odot$ are systematically higher than those for globular clusters which have mass ratios near unity. However, at the very highest masses in our sample, i.e. 10^9 – 10^{10} $M_\odot$, we find that cE galaxies also have mass ratios of close to unity, indicating their central regions are mostly composed of stars. Suggested explanations for the elevated mass ratios of UCDs have included a variable IMF, a central black hole, and the presence of dark matter. Here we present another possible explanation, i.e. tidal stripping. Under various assumptions, we find that the apparent variation in the mass ratio with stellar mass and stellar density can be qualitatively reproduced by published tidal stripping simulations of a dwarf elliptical galaxy. In the early stages of the stripping process the galaxy is unlikely to be in virial equilibrium. At late stages, the final remnant resembles the properties of $\sim 10^7$ $M_\odot$ UCDs. Finally, we discuss the need for more detailed realistic modelling of tidal stripping over a wider range of parameter space, and observations to further test the stripping hypothesis.

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`http://fr.arxiv.org/abs/1408.2558`

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The outer halo globular cluster system of M31 - I. The final PAndAS catalogue

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We report the discovery of 59 globular clusters (GCs) and two candidate GCs in a search of the halo of M31, primarily via visual inspection of Canada-France-Hawaii Telescope/MegaCam imagery from the Pan Andromeda Archaeological Survey (PAndAS). The superior quality of these data also allows us to check the classification of remote objects in the Revised Bologna Catalogue (RBC), plus a subset of GC candidates drawn from Sloan Digital Sky Survey (SDSS) imaging. We identify three additional new GCs from the RBC, and confirm the GC nature of 11 SDSS objects (8 of which appear independently in our remote halo catalogue); the remaining 188 candidates across both lists are either foreground stars or background galaxies. Our new catalogue represents the first uniform census of GCs across the M31 halo - we find clusters to the limit of the PAndAS survey area at projected radii of up to Rp $\sim$ 150 kpc. Tests using artificial clusters reveal that detection incompleteness cuts in at luminosities below $M_V = -6.0$; our 50 per cent completeness limit is $M_V = -4.1$. We construct a uniform set of PAndAS photometric measurements for all known GCs outside Rp = 25 kpc, and any new GCs within this radius. With these data, we update results from Huxor et al. (2011), investigating the luminosity function (LF), colours and effective radii of M31 GCs with a particular focus on the remote halo. We find that the GCLF is clearly bimodal in the outer halo (Rp $>$ 30 kpc), with the secondary peak at $M_V = -5.5$. We argue that the GCs in this peak have most likely been

accreted along with their host dwarf galaxies. Notwithstanding, we also find, as in previous surveys, a substantial number of GCs with above-average luminosity in the outer M31 halo - a population with no clear counterpart in the Milky Way.

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The Snapshot Hubble U-Band Cluster Survey (SHUCS). II. The Star Cluster Population of NGC 2997

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We study the star cluster population of NGC 2997, a giant spiral galaxy located at 9.5 Mpc and targeted by the Snapshot *Hubble* U-band Cluster Survey (SHUCS). Combining our U-band imaging from SHUCS with archival BVI imaging from HST, we select a high confidence sample of clusters in the circumnuclear ring and disk through a combination of automatic detection procedures and visual inspection. The cluster luminosity functions in all four filters can be approximated by power-laws with indices of -1.7 to -2.3. Some deviations from pure power-law shape are observed, hinting at the presence of a high-mass truncation in the cluster mass function. However, upon inspection of the cluster mass function, we find it is consistent with a pure power-law of index -2.2 ± 0.2 despite a slight bend at $\sim 2.5 \times 10^4$ $M_\odot$. No statistically significant truncation is observed. From the cluster age distributions, we find a low rate of disruption ($\zeta \sim -0.1$) in both the disk and circumnuclear ring. Finally, we estimate the cluster formation efficiency (Γ) over the last 100 Myr in each region, finding $7 \pm 2\%$ for the disk, $12 \pm 4\%$ for the circumnuclear ring, and $10 \pm 3\%$ for the entire $UBVI$ footprint. This study highlights the need for wide-field $UBVI$ coverage of galaxies to study cluster populations in detail, though a small sample of clusters can provide significant insight into the characteristics of the population.

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The outer halo globular cluster system of M31 - II. Kinematics

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We present a detailed kinematic analysis of the outer halo globular cluster system of the Andromeda galaxy (M31). Our basis for this is a set of new spectroscopic observations for 78 clusters lying at projected distances between Rp = 20–140 kpc from the M31 centre. These are largely drawn from the recent Pan-Andromeda Archaeological Survey globular cluster catalogue; 63 of our targets have no previous velocity data. Via a Bayesian maximum likelihood analysis, we find that globular clusters with Rp > 30 kpc exhibit coherent rotation around the minor optical axis of M31, in the same direction as more centrally located globular clusters, but with a smaller amplitude of 86 ± 17 km s^{-1}. There is also evidence that the velocity dispersion of the outer halo globular cluster system decreases as a function of projected distance from the M31 centre, and that this relation can be well described by a power law of index ~ -0.5. The velocity dispersion profile of the outer halo globular clusters is quite similar to that of the halo stars, at least out to the radius up to which there is available information on the stellar kinematics. We detect and discuss various velocity correlations amongst subgroups of

globular clusters that lie on stellar debris streams in the M31 halo. Many of these subgroups are dynamically cold, exhibiting internal velocity dispersions consistent with zero. Simple Monte Carlo experiments imply that such configurations are unlikely to form by chance, adding weight to the notion that a significant fraction of the outer halo globular clusters in M31 have been accreted alongside their parent dwarf galaxies. We also estimate the M31 mass within 200 kpc via the Tracer Mass Estimator (TME), finding (1.2–1.6) $\pm$ 0.2 $\times$ 10^{12} $M_{\odot}$. This quantity is subject to additional systematic effects due to various limitations of the data, and assumptions built in into the TME. Finally, we discuss our results in the context of formation scenarios for the M31 halo.

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Faint X-Ray Binaries and Their Optical Counterparts in M31

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X-ray binaries (XRBs) are probes of both star formation and stellar mass, but more importantly remain one of the only direct tracers of the compact object population. To investigate the XRB population in M31, we utilized all 121 publicly available observations of M31 totalling over 1 Ms from Chandra's ACIS instrument. We studied 83 star clusters in the bulge using the year 1 star cluster catalogue from the Panchromatic Hubble Andromeda Treasury Survey. We found 15 unique star clusters that matched to 17 X-ray point sources within 1″ (3.8 pc). This population is composed predominantly of globular cluster low-mass XRBs, with one previously unidentified star cluster X-ray source. Star clusters that were brighter and more compact preferentially hosted an X-ray source. Specifically, logistic regression showed that the F475W magnitude was the most important predictor followed by the effective radius, while color (F475W–F814W) was not statistically significant. We also completed a matching analysis of 1566 HII regions and found 10 unique matches to 9 X-ray point sources within 3″ (11 pc). The HII regions hosting X-ray point sources were on average more compact than unmatched HII regions, but logistic regression concluded that neither the radius nor H-alpha luminosity was a significant predictor. Four matches have no previous classification and thus are high-mass XRB candidates. A stacking analysis of both star clusters and HII regions resulted in non-detections, giving typical upper limits of 10^{32} erg/s, which probes the quiescent XRB regime.

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Dynamical evolution - Simulations

A prescription and fast code for the long-term evolution of star clusters - III. Unequal masses and stellar evolution

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We present a new version of the fast star cluster evolution code EVOLVE ME A CLUSTER OF STARS (EMACSS). While previous versions of EMACSS reproduced clusters of single-mass stars, this version models clusters with an evolving stellar content. Stellar evolution dominates early evolution, and leads to: (1) reduction of the mean mass of stars due to the mass loss of high-mass stars; (2) expansion of the half-mass radius; (3) for (nearly) Roche Volume filling clusters, the induced escape of stars. Once sufficient relaxation has occurred ($\simeq$10 relaxation times-scales), clusters reach a second, 'balanced' state whereby the core releases energy as required by the cluster as a whole. In this state: (1) stars escape due to tidal effects faster than before balanced evolution; (2) the half-mass radius expands or contracts depending on the Roche volume filling factor; and (3) the mean mass of stars increases due to the preferential ejection of low-mass stars. We compare the EMACSS results of several cluster properties against N-body simulations of clusters spanning a range of initial number of stars, mass, half-mass radius, and tidal environments, and show that our prescription accurately predicts cluster evolution for this data base. Finally, we consider applications for EMACSS, such as studies of galactic globular cluster populations in cosmological simulations.

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Effect of dynamical interactions on integrated properties of globular clusters

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Globular Clusters (GCs) are generally treated as natural validators of simple stellar population (SSP) models. However, there are still some differences between real GCs and SSPs. In this work we use a direct N-body simulation code Nbody6 to study the influences of dynamical interactions, metallicity and primordial binaries on Milky Way globular clusters' integrated properties. Our models start with $N = 100,000$ stars, covering a metallicity range $Z = 0.0001 \sim 0.02$, a subset of our models contain primordial binaries, resulting in a binary fraction as currently observed at a model age of GCs. Stellar evolution and external tidal field representative for an average Milky Way GC are taken into consideration. The integrated colours and Lick indices are calculated using BaSeL and Bluered stellar spectral libraries separately. By including dynamical interactions, our model clusters show integrated features (i.e. colours up to 0.01mag bluer, Hβ up to 0.1Å greater and [MgFe]$'$ 0.05Å smaller) making the clusters appear slightly younger than the model clusters without dynamical interactions. This effect is caused mainly by the preferential loss of low-mass stars which have a stronger contribution

to redder passbands as well as different spectral features compared to higher-mass stars. In addition, this effect is larger at lower metallicities. On the contrary, the incorporation of primordial binaries reduces this effect.

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Miscellaneous

Galactic globular and open cluster fiducial sequences in the Pan-STARRS1 photometric system

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We present the fiducial sequences of a sample of Galactic star clusters in the five bands of the Pan-STARRS1 (PS1) photometric system (g_{P1}, r_{P1}, i_{P1}, z_{P1}, and y_{P1}). These empirical sequences – which include the red giant and sub-giant branches, the main sequence, and the horizontal branch – were defined from deep colour-magnitude diagrams reaching below the oldest main-sequence turn-offs of 13 globular and 3 old open clusters covering a wide range of metallicities ($-2.4 \lesssim$ [Fe/H] $\lesssim +0.4$). We find excellent agreement for the nine clusters in common with previous studies in similar photometric systems when transformed to the PS1 system. Because the photometric and spectroscopic properties of these stellar populations are accurately known, the fiducials provide a solid basis for the interpretation of observations in the PS1 system, as well as valuable constraints to improve the empirical colour-T_{eff} relations.

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New Galactic embedded clusters and candidates from a WISE Survey

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We carried out a search for new infrared star clusters, stellar groups and candidates using WISE images, which are very sensitive to dust emission nebulae. We report the discovery of 437 embedded clusters and stellar groups that show a variety of structures, both in the stellar and nebular components. Pairs or small groupings of clusters are observed, suggesting multiple generations at the early formation stages. The resulting catalogue provides Galactic and equatorial coordinates, together with angular sizes for all objects. The nature of a representative test sub-sample of 14 clusters is investigated in detail by means of 2MASS photometry. The colour magnitude diagrams and radial density distributions characterize them as stellar clusters. The 437 new objects were found in the ranges $145° \leq l \leq 290°$and $-25° \leq b \leq 20°$, and they appear to be a major object source for future studies of star cluster formation and their early evolution. WISE is a powerful tool to further probe for very young clusters throughout the disk.

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Global survey of star clusters in the Milky Way III. 139 new open clusters at high Galactic latitudes

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An earlier analysis of the Milky Way Star Cluster (MWSC) catalogue revealed an apparent lack of old ($t \gtrsim 1\,\mathrm{Gyr}$) open clusters in the solar neighbourhood ($d \lesssim 1\,\mathrm{kpc}$). To fill this gap we undertook a search for hitherto unknown star clusters, assuming that the missing old clusters reside at high Galactic latitudes $|b| > 20°$. We were looking for stellar density enhancements using a star count algorithm on the 2MASS point source catalogue. To increase the contrast between potential clusters and the field, we applied filters in colour-magnitude space according to typical colour-magnitude diagrams of nearby old open clusters. The subsequent comparison with lists of known objects allowed us to select thus far unknown cluster candidates. For verification they were processed with the standard pipeline used within the MWSC survey for computing cluster membership probabilities and for determining structural, kinematic, and astrophysical parameters. In total we discovered 782 density enhancements, 522 of which were classified as real objects. Among them 139 are new open clusters with ages $8.3 < \log(t\ [\mathrm{yr}]) < 9.7$, distances $d < 3\,\mathrm{kpc}$, and distances from the Galactic plane $0.3 < Z < 1\,\mathrm{kpc}$. This new sample has increased the total number of known high latitude open clusters by about 150%. Nevertheless, we still observe a lack of older nearby clusters up to 1 kpc from the Sun. This volume is expected to still contain about 60 unknown clusters that probably escaped our detection algorithm, which fails to detect sparse overdensities with large angular size.

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Conferences

GES 2014: Gaia-ESO Survey Second Science Meeting

10-13 November, 2014
Porto (Portugal)
http://www.astro.up.pt/investigacao/conferencias/ges2014/

early registration / abstract submission deadline: Sept. 10, 2014

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MODEST 15
Modelling and Observing Dense Stellar Systems in Chile

2-6 March, 2015
Concepción (Chile)
http://www.astro-udec.cl/modest15/