The Star Clusters Young & Old Newsletter

edited by Giovanni Carraro, Martin Netopil, and Ernst Paunzen
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EDITORIAL

Dear subscribers,

After a quite long break, the SCYON Newsletter is back with a new editor team:

- Giovanni Carraro - ESO Chile
- Martin Netopil - University of Vienna, Austria
- Ernst Paunzen - Masaryk University, Brno, Czech Republic

We would like to thank Holger Baumgardt, the former editor, for taking care of the Newsletter in the past and for his help to relaunch it!

Furthermore, a new Newsletter layout and webpage was designed. The latter lists always new submissions since the last issue - so visit the webpage frequently!

This new issue contains 34 refereed and proceedings abstracts, announcements of upcoming conferences, the 2^{nd} data release of the IPHAS galactic plane survey, and Job opportunities. We expect the coming issues to be even more extended, and we look forward to have everybody's help to disseminate this Newsletter everywhere!

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

Galactic Open Clusters

Five old open clusters more in the outer Galactic disc

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New photometric material is presented for 6 outer disk supposedly old, Galactic star clusters: Berkeley 76, Haffner 4, Ruprecht 10, Haffner 7, Haffner 11, and Haffner 15, that are projected against the rich and complex Canis Major overdensity at $225 < l < 248$, $-7 < b < -2$. This CCD data-set, in the UBVI pass-bands, is used to derive their fundamental parameters, in particular age and distance. Four of the program clusters turn out to be older than 1 Gyr. This fact makes them ideal targets for future spectroscopic campaigns aiming at deriving their metal abundances. This, in turn, contributes to increase the number of well-studied outer disk old open clusters. Only Haffner 15, previously considered an old cluster, is found to be a young, significantly reddened cluster, member of the Perseus arm in the third Galactic quadrant. As for Haffner 4, we suggest an age of about half a Gyr. The most interesting result we found is that Berkeley 76 is probably located at more than 17 kpc from the Galactic center, and therefore is among the most peripherical old open clusters so far detected. Besides, for Ruprecht 10 and Haffner 7, which were never studied before, we propose ages larger than 1 Gyr. All the old clusters of this sample are scarcely populated and show evidence of tidal interaction with the Milky Way, and are therefore most probably in advanced stages of dynamical dissolution.

Accepted by : Monthly Notices of the Royal Astronomical Society

http://arxiv.org/abs/1209.4942

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UB CCD photometry of the old, metal rich, open clusters NGC 6791, NGC 6819 and NGC 7142

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We report on a UV-oriented imaging survey in the fields of the old, metal-rich open clusters, NGC 6791, NGC 6819 and NGC 7142. These three clusters represent both very near and ideal stellar aggregates to match the distinctive properties of the evolved stellar populations, as in elliptical galaxies and bulges of spirals. The CMD of the three clusters is analyzed in detail, with special emphasis to the hot stellar component. We report, in this regard, one new extreme horizontal-branch star candidate in NGC 6791. For NGC 6819 and 7142, the stellar luminosity function points to a looser radial distribution of faint lower Main Sequence stars, either as a consequence of cluster dynamical interaction with the Galaxy or as an effect of an increasing fraction of binary stars toward the cluster core, as actually observed in NGC 6791 too.

Accepted by : Astronomical Journal

http://arxiv.org/abs/1309.4100

The distance to the young open cluster Westerlund 2

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A new X-ray, $UBVRI_c$, and JHK_s study of the young cluster Westerlund 2 was undertaken to resolve discrepancies tied to the cluster's distance. Existing spectroscopic observations for bright cluster members and new multi-band photometry imply a reddening relation towards Westerlund 2 described by $E_{U-B}/E_{B-V} = 0.63 + 0.02\ E_{B-V}$. Variable-extinction analyses for Westerlund 2 and nearby IC 2581 based upon spectroscopic distance moduli and ZAMS fitting yield values of $R_V = A_V/E_{B-V} = 3.88 \pm 0.18$ and 3.77 ± 0.19, respectively, and confirm prior assertions that anomalous interstellar extinction is widespread throughout Carina (e.g., Turner 2012). The results were confirmed by applying the color difference method to $UBVRI_cJHK_s$ data for 19 spectroscopically-observed cluster members, yielding $R_V = 3.85 \pm 0.07$. The derived distance to Westerlund 2 of $d = 2.85 \pm 0.43$ kpc places the cluster on the far side of the Carina spiral arm. The cluster's age is no more than $\tau \sim 2 \times 10^6$ yr as inferred from the cluster's brightest stars and an X-ray (Chandra) cleaned analysis of its pre-main-sequence demographic. Four Wolf-Rayet stars in the cluster core and surrounding corona (WR20a, WR20b, WR20c, and WR20aa) are likely cluster members, and their inferred luminosities are consistent with those of other late-WN stars in open clusters. The color-magnitude diagram for Westerlund 2 also displays a gap at spectral type B0.5 V with associated color spread at higher and lower absolute magnitudes that might be linked to close binary mergers. Such features, in conjunction with the evidence for mass loss from the WR stars, may help to explain the high flux of γ rays, cosmic rays, and X-rays from the direction towards Westerlund 2.

Accepted by : Astronomy & Astrophysics

http://arxiv.org/abs/1305.4309

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The Main Sequence of three Red Supergiant Clusters

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Massive clusters in our Galaxy are an ideal testbed to investigate the properties and evolution of high mass stars. They provide statistically significant samples of massive stars of uniform ages. To accurately determine the intrinsic physical properties of these stars we need to establish the distances, ages and reddening of the clusters. One avenue to achieve this is the identification and characterisation of the main sequence members of red supergiant rich clusters. Here we utilise publicly available data from the UKIDSS galactic plane survey. We show that point spread function photometry in conjunction with standard photometric decontamination techniques allows us to identify the most likely main sequence members in the 10-20 Myr old clusters RSGC1, 2, and 3. We confirm the previous detection of the main sequence in RSGC2 and provide the first main sequence detection in RSGC1 and RSGC3. There are in excess of 100 stars with more than $8M_\odot$identified in each cluster. These main sequence members are concentrated towards the spectroscopically confirmed red supergiant stars. We utilise the J-K colours of the bright main sequence stars to determine the K-band extinction towards the clusters. The differential reddening is three times as large in the youngest cluster RSGC1 compared to the two older clusters RSGC2 and RSGC3. Spectroscopic follow up of the cluster main

sequence stars should lead to more precise distance and age estimates for these clusters as well as the determination of the stellar mass function in these high mass environments.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://astro.kent.ac.uk/~df/

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Anchors for the Cosmic Distance Scale: the Cepheid QZ Normae in the Open Cluster NGC 6067

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Cepheids are key to establishing the cosmic distance scale. Therefore it's important to assess the viability of QZ Nor, V340 Nor, and GU Nor as calibrators for Leavitt's law via their purported membership in the open cluster NGC 6067. The following suite of evidence confirms that QZ Nor and V340 Nor are members of NGC 6067, whereas GU Nor likely lies in the foreground: (i) existing radial velocities for QZ Nor and V340 Nor agree with that established for the cluster (-39.4 ± 1.2 km/s) to within 1 km/s, whereas GU Nor exhibits a markedly smaller value; (ii) a steep velocity-distance gradient characterizes the sight-line toward NGC 6067, thus implying that objects sharing common velocities are nearly equidistant; (iii) a radial profile constructed for NGC 6067 indicates that QZ Nor is within the cluster bounds, despite being $20'$from the cluster center; (iv) new BVJH photometry for NGC 6067 confirms the cluster lies $d=1.75\pm0.10$ kpc distant, a result that matches Wesenheit distances computed for QZ Nor/V340 Nor using the Benedict et al. (2007, HST parallaxes) calibration. QZ Nor is a cluster Cepheid that should be employed as a calibrator for the cosmic distance scale.

Accepted by : Astrophysics and Space Science
http://arxiv.org/abs/1305.3914

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Towards a photometric metallicity scale for open clusters

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Open clusters are a useful tool when investigating several topics connected with stellar evolution; for example the age or distance can be more accurately determined than for field stars. However, one important parameter, the metallicity, is only known for a marginal percentage of open clusters. We aim at a consistent set of parameters for the open clusters investigated in our photometric Delta-a survey of chemically peculiar stars. Special attention is paid to expanding our knowledge of cluster metallicities and verifying their scale. Making use of a previously developed method based on normalised evolutionary grids and photometric data, the distance, age, reddening, and metallicity of open clusters were derived. To transform photometric measurements into effective temperatures to use as input for our method, a set of temperature calibrations for the most commonly used colour indices and photometric systems was compiled. We analysed 58 open clusters in total. Our derived metallicity values were in excellent agreement with about 30 spectroscopically studied targets. The mean value of the absolute deviations was found to be 0.03 dex, with no noticeable offset or gradient. The method was also applied using recent evolutionary models based on the currently accepted lower solar abundance value $Z=0.014$. No significant differences were found compared to grids using the

former adopted solar value Z=0.02. Furthermore, some divergent photometric datasets were identified and discussed. The method provides an accurate way of obtaining properly scaled metallicity values for open clusters. In light of present and future homogeneous photometric sky surveys, the sample of stellar clusters can be extended to the outskirts of the Milky Way, where spectroscopic studies are almost impossible. This will help for determining galactic metallicity gradients in more detail.

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http://arxiv.org/abs/1307.2094

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Fitting isochrones to open cluster photometric data III. Estimating metallicities from UBV photometry

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The metallicity is a critical parameter that affects the correct determination fundamental characteristics stellar cluster and has important implications in Galactic and Stellar evolution research. Fewer than 10% of the 2174 currently catalog open clusters have their metallicity determined in the literature. In this work we present a method for estimating the metallicity of open clusters via non-subjective isochrone fitting using the cross-entropy global optimization algorithm applied to UBV photometric data. The free parameters distance, reddening, age, and metallicity simultaneously determined by the fitting method. The fitting procedure uses weights for the observational data based on the estimation of membership likelihood for each star, which considers the observational magnitude limit, the density profile of stars as a function of radius from the center of the cluster, and the density of stars in multi-dimensional magnitude space. We present results of [Fe/H] for nine well-studied open clusters based on 15 distinct UBV data sets. The [Fe/H] values obtained in the ten cases for which spectroscopic determinations were available in the literature agree, indicating that our method provides a good alternative to determining [Fe/H] by using an objective isochrone fitting. Our results show that the typical precision is about 0.1 dex.

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Galactic Globular Clusters

Early disc accretion as the origin of abundance anomalies in globular clusters

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Globular clusters (GCs), once thought to be well approximated as simple stellar populations (i.e. all stars having the same age and chemical abundance), are now known to host a variety of anomalies, such as multiple discrete (or spreads in) populations in colour-magnitude diagrams and abundance variations in light elements (e.g. Na, O, Al). Multiple models have been put forward to explain the observed anomalies, although all have serious shortcomings (e.g. requiring a non-standard initial mass function of stars and GCs to have been initially 10−100 times more massive than observed today). These models also do not agree with observations of massive stellar clusters forming today, which do not display significant age spreads nor have gas/dust within the cluster. Here we present a model for the formation of GCs, where low-mass pre-main-sequence stars accrete enriched material released from interacting massive binary and rapidly rotating stars on to their circumstellar discs, and ultimately on to the young stars. As was shown in previous studies, the accreted material matches the unusual abundances and patterns observed in GCs. The proposed model does not require multiple generations of star formation, conforms to the known properties of massive clusters forming today and solves the 'mass budget problem' without requiring GCs to have been significantly more massive at birth. Potential caveats to the model as well as model predictions are discussed.

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http://arxiv.org/abs/1309.3566

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Ruprecht 106: the first single population Globular Cluster?

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All old Galactic Globular Clusters studied in detail to date host at least two generations of stars, where the second is formed from gas polluted by processed material produced by massive stars of the first. This process can happen if the initial mass of the cluster exceeds a threshold above which ejecta are retained and a second generation is formed. A determination of this mass-threshold is mandatory in order to understand how GCs form. We analyzed 9 RGB stars belonging to the cluster Ruprecht 106. Targets were observed with the UVES@VLT2 spectrograph. Spectra cover a wide range and allowed us to measure abundances for light (O,Na,Mg,Al), α(Si,Ca,Ti) , iron-peak (Sc,V,Cr,Mn,Fe,Co,Ni,Cu,Zn) and neutron- capture (Y,Zr,Ba,La,Ce,Pr,Nd,Sm,Eu,Dy,Pb) elements. Based on these abundances we show that Ruprecht 106 is the first convincing example of a single population GC. This result is supported also by an independent photometric test and by the HB morphology. It is old ($\sim$12 Gyrs) and, at odds with other GCs, it has no α-enhancement. The material it formed from was contaminated by both s- and r- process elements. The abundance pattern points toward an extragalactic origin. Its present day mass (M=104.83 $M_\odot$) can be assumed as a lower limit for the initial mass threshold below which no second generation is formed. Clearly, its initial mass was significantly greater but we have no current constraints on the amount of mass loss during its evolution.

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http://arxiv.org/abs/1310.5900v1

Clusters in the Magellanic clouds

Constraints on possible age spreads within young massive clusters in the Large Magellanic Cloud

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Recent studies have shown that the observed main-sequence turnoff (MSTO) in colour-magnitude diagrams of intermediate-age (1−2 Gyr) clusters in the Large Magellanic Cloud (LMC) is broader than would be nominally expected for a simple stellar population. This has led to the suggestion that such clusters may host multiple stellar populations, with age spreads of 100−500 Myr. However, at intermediate ages, spreads of this magnitude are difficult to discern and alternative explanations have been put forward (e.g. stellar rotation, interacting binaries). A prediction of the age-spread scenario is that younger clusters in the LMC, with similar masses and radii, should also show significant age spreads. In younger clusters (i.e. 40−300 Myr), such large age spreads should be readily apparent. We present an analysis of the colour-magnitude diagrams of two massive young clusters in the LMC (NGC 1856 and NGC 1866) and show that neither have such large age spreads; in fact, both are consistent with a single burst of star formation [σ(age) $<$ 35 Myr]. This leads us to conclude that either the intermediate-age clusters in the LMC are somehow special or the broadened MSTOs are not due to an age spread within the clusters.

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`http://adsabs.harvard.edu/abs/2013MNRAS.431L.122B`

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No compelling evidence of significant early star cluster disruption in the Large Magellanic Cloud

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Whether or not the rich star cluster population in the Large Magellanic Cloud (LMC) is affected by significant disruption during the first few times 10^8 yr of its evolution is an open question and the subject of significant current debate. Here, we revisit the problem, adopting a homogeneous data set of broad-band imaging observations. We base our analysis mainly on two sets of self-consistently determined LMC cluster ages and masses, one using standard modelling and one which takes into account the effects of stochasticity in the clusters' stellar mass functions. On their own, the results based on any of the three complementary analysis approaches applied here are merely indicative of the physical conditions governing the cluster population. However, the combination of our results from all three different diagnostics leaves little room for any conclusion other than that the optically selected LMC star cluster population exhibits no compelling evidence of significant disruption – for clusters with masses, M_{cl}, of $M_{cl}/M_{\odot} \gtrsim$ 3.0–3.5 – between the age ranges of [3–10] Myr and [30–100] Myr, either "infant mortality" or otherwise. In fact, there is no evidence of any destruction beyond that expected from simple models just including stellar dynamics and stellar evolution for ages up to 1 Gyr. It seems, therefore, that the difference in environmental conditions in the Magellanic Clouds

on the one hand and significantly more massive galaxies on the other may be the key to understanding the apparent variations in cluster disruption behaviour at early times.

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http://arxiv.org/abs/1308.3296

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Gravitational conundrum? Dynamical mass segregation versus disruption of binary stars in dense stellar systems

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Upon their formation, dynamically cool (collapsing) star clusters will, within only a few million years, achieve stellar mass segregation for stars down to a few solar masses, simply because of gravitational two-body encounters. Since binary systems are, on average, more massive than single stars, one would expect them to also rapidly mass segregate dynamically. Contrary to these expectations and based on high-resolution *Hubble Space Telescope* observations, we show that the compact, 15–30 Myr-old Large Magellanic Cloud cluster NGC 1818 exhibits tantalizing hints at the $\gtrsim 2\sigma$ level of significance ($> 3\sigma$ if we assume a power-law secondary-to-primary mass-ratio distribution) of an increasing fraction of F-star binary systems (with combined masses of 1.3–1.6 $M_\odot$) with increasing distance from the cluster center, specifically between the inner 10 to 20$''$ (approximately equivalent to the cluster's core and half-mass radii) and the outer 60 to 80$''$. If confirmed, this will offer support of the theoretically predicted but thus far unobserved dynamical disruption processes of the significant population of 'soft' binary systems – with relatively low binding energies compared to the kinetic energy of their stellar members – in star clusters, which we have access to here by virtue of the cluster's unique combination of youth and high stellar density.

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http://arxiv.org/abs/1301.1926

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The binary fractions in the massive young Large Magellanic Cloud star clusters NGC 1805 and NGC 1818

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Using high-resolution data sets obtained with the Hubble Space Telescope, we investigate the radial distributions of the F-type main-sequence binary fractions in the massive young Large Magellanic Cloud star clusters NGC 1805 and NGC 1818. We apply both an isochrone-fitting approach and χ^2 minimization using Monte Carlo simulations, for different mass-ratio cut-offs, q, and present a detailed comparison of the methods' performance. Both methods yield the same radial binary fraction profile for the same cluster, which therefore supports the robustness and applicability of either method to young star clusters which are as yet unaffected by the presence of multiple stellar populations. The binary fractions in these two clusters are characterized by opposite trends in their radial profiles. NGC 1805 exhibits a decreasing trend with increasing radius in the central region, followed by a slow increase to the field's binary-fraction level, while NGC 1818 shows a monotonically increasing trend. This may

indicate dominance of a more complicated physical mechanism in the cluster's central region than expected a priori. Time-scale arguments imply that early dynamical mass segregation should be very efficient and, hence, likely dominates the dynamical processes in the core of NGC 1805. Meanwhile, in NGC 1818 the behavior in the core is probably dominated by disruption of soft binary systems. We speculate that this may be owing to the higher velocity dispersion in the NGC 1818 core, which creates an environment in which the efficiency of binary disruption is high compared with that in the NGC 1805 core.

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`http://mnras.oxfordjournals.org/content/early/2013/09/25/mnras.stt1669.full.pdf`

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Blue Straggler evolution caught in the act in the Large Magellanic Cloud Globular cluster Hodge 11

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High-resolution Hubble Space Telescope imaging observations show that the radial distribution of the field- decontaminated sample of 162 “blue straggler” stars (BSs) in the $11.7^{+0.2}_{-0.1}$ Gyr old Large Magellanic Cloud cluster Hodge 11 exhibits a clear bimodality. In combination with their distinct loci in color-magnitude space, this offers new evidence in support of theoretical expectations that suggest different BS formation channels as a function of stellar density. In the cluster's color-magnitude diagram, the BSs in the inner $15''$ (roughly corresponding to the cluster's core radius) are located more closely to the theoretical sequence resulting from stellar collisions, while those in the periphery (at radii between $85''$ and $100''$) are preferentially found in the region expected to contain objects formed through binary mass transfer or coalescence. In addition, the objects' distribution in color-magnitude space provides us with the rare opportunity in an extragalactic environment to quantify the evolution of the cluster's collisionally induced BS population and the likely period that has elapsed since their formation epoch, which we estimate to have occurred $\sim$4$-$5 Gyr ago.

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`http://iopscience.iop.org/2041-8205/770/1/L7/pdf/apjl_770_1_7.pdf`

The most distant clusters

M31 globular cluster structures and the presence of X-ray binaries

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University of Western Ontario

The Andromeda galaxy, M31, has several times the number of globular clusters found in the Milky Way. It contains a correspondingly larger number of low mass X-ray binaries (LMXBs) associated with globular clusters, and as such can be used to investigate the cluster properties which lead to X-ray binary formation. The best tracer of the spatial structure of M31 globulars is the high-resolution imaging available from the Hubble Space Telescope (HST), and we have used HST data to derive structural parameters for 29 LMXB-hosting M31 globular clusters. These measurements are combined with structural parameters from the literature for a total of 41 (of 50 known) LMXB clusters and a comparison sample of 65 non-LMXB clusters. Structural parameters measured in blue bandpasses are found to be slightly different (smaller core radii and higher concentrations) than those measured in red bandpasses; this difference is enhanced in LMXB clusters and could be related to stellar population differences. Clusters with LMXBs show higher collision rates for their mass compared to clusters without LMXBs and collision rates estimated at the core radius show larger offsets than rates estimated at the half-light radius. These results are consistent with the dynamical formation scenario for LMXBs. A logistic regression analysis finds that, as expected, the probability of a cluster hosting an LMXB increases with increasing collision rate and proximity to the galaxy center. The same analysis finds that probability of a cluster hosting an LMXB decreases with increasing cluster mass at a fixed collision rate, although we caution that this could be due to sample selection effects. Metallicity is found to be a less important predictor of LMXB probability than collision rate, mass, or distance, even though LMXB clusters have a higher metallicity on average. This may be due to the interaction of location and metallicity: a sample of M31 LMXBs with a greater range in galactocentric distance would likely contain more metal-poor clusters and make it possible to disentangle the two effects.

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`http://arxiv.org/abs/1308.6748`

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Luminosity profiles and sizes of massive star clusters in NGC 7252

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We present Hubble Space Telescope (HST) Wide-Field Camera 3 (WFC3) images of the merger remnant NGC 7252. In particular, we focus on the surface brightness profiles and effective radii Reff of 36 young massive clusters (YMCs) within the galaxy. All the clusters have masses exceeding 105 $M_\odot$; and are, despite the 64 Mpc distance to the galaxy, (partly) resolved on the HST images. Effective radii can be measured down to $\sim$2.5 pc, and the largest clusters have Reff approaching 20 pc. The median Reff of our sample clusters is $\sim$6$-$7 pc, which is larger than typical radii of YMCs ($\sim$2.5 pc). This could be due to our sample selection (only selecting resolved sources) or to an intrinsic mass-radius relation within the cluster population. We find at least three clusters that have power-law profiles of the Elson, Fall and Freeman (EFF) type extending out to $\gtrsim$ 150 pc. Among them are the two most massive clusters, W3 and W30, which have profiles that extend to at least 500 and 250 pc, respectively. Despite their extended profiles, the effective radii of the three clusters are 17.2, 12.6 and 9.1 pc for W3, W26 and W30, respectively. We compare these extended profiles with those of YMCs in the Large Magellanic Cloud (R136 in 30 Dor), the Antennae galaxies (Knot S) and in

the nearby spiral galaxy NGC 6946. Extended profiles seem to be a somewhat common feature, even though many nearby YMCs show distinct truncations. A continuous distribution between these two extremes, i.e. truncated or extremely extended, is the most likely interpretation. We suggest that the presence or absence of an extended envelope in very young clusters may be due to the gas distribution of the proto-cluster giant molecular cloud, in particular if the proto-cluster core becomes distinct from the surrounding gas before star formation begins.

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The NGC 5253 star cluster system. I. Standard modelling and infrared-excess sources

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Using high-resolution *Hubble Space Telescope* data, we reexamine the fundamental properties (ages, masses and extinction values) of the rich star cluster population in the dwarf starburst galaxy NGC 5253. The gain in resolution compared to previous studies is of order a factor of two in both spatial dimensions, while our accessible wavelength range transcends previous studies by incorporation of both near-ultraviolet and near-infrared (IR) passbands. We apply spectral synthesis treatments based on two different simple stellar population model suites to our set of medium-, broad-band and Hα images to gain an improved physical understanding of the IR-excess flux found for a subset of young clusters (30 of 149). With the caveat that our models are based on fully sampled stellar mass functions, the NGC 5253 cluster population is dominated by a significant number of relatively low-mass ($M_{\rm cl} \lesssim$ a few 10^4 M$_\odot$) objects with ages ranging from a few $\times 10^6$ to a few $\times 10^7$ yr, which is in excellent agreement with the starburst age of the host galaxy. The IR-excess clusters are almost all found in this young age range and have masses of up to a few $\times 10^4$ M$_\odot$. The IR excess in the relatively low-mass NGC 5253 clusters is most likely caused by a combination of stochastic sampling effects and colour variations due to the presence of either luminous red or pre-main-sequence stars. We also find a small number of intermediate-age ($\sim$ 1 Gyr-old), $\sim 10^5$ M$_\odot$ clusters, as well as up to a dozen massive, $\sim$ 10 Gyr-old globular clusters. Their presence supports the notion that NGC 5253 is a very active galaxy that has undergone multiple episodes of star cluster formation.

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The Snapshot Hubble U-Band Cluster Survey (SHUCS). I. Survey Description and First Application to the Mixed Star Cluster Population of NGC 4041

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We present the Snapshot *Hubble* U-band Cluster Survey (SHUCS), a project aimed at characterizing the star cluster populations of ten nearby galaxies ($d < 23$ Mpc, half within ≈ 12 Mpc) through new F336W (U band equivalent) imaging from Wide Field Camera 3, and archival BVI-equivalent data with the *Hubble Space Telescope.* Completing the *UBVI* baseline reduces the age-extinction degeneracy of optical colours, thus enabling the measurement of reliable ages and masses for the thousands of clusters covered by our survey. The sample consists chiefly of face-on spiral galaxies at low inclination, in various degrees of isolation (isolated, in group, merging), and includes two AGN hosts. This first paper outlines the survey itself, the observational datasets, the analysis methods, and presents a proof-of-concept study of the large-scale properties and star cluster population of NGC 4041, a massive SAbc galaxy at a distance of ≈ 23 Mpc, and part of a small grouping of six giant members. We resolve two structural components with distinct stellar populations, a morphology more akin to merging and interacting systems. We also find strong evidence of a truncated, Schechter-type mass function, and a similarly segmented luminosity function. These results indicate that binning must erase much of the substructure present in the mass and luminosity functions, and might account for the conflicting reports on the intrinsic shape of these functions in the literature. We also note a tidal feature in the outskirts of the galaxy in *GALEX* UV imaging, and follow it up with a comprehensive multi-wavelength study of NGC 4041 and its parent group. We deduce a minor merger as a likely cause of its segmented structure and the observed pattern of a radially decreasing star formation rate. We propose that combining the study of star cluster populations with broad-band metrics is not only advantageous, but often easily achievable thorough archival datasets.

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http://arxiv.org/abs/1302.6598

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The Next Generation Virgo Cluster Survey – Infrared (NGVS-IR): I. A new Near-UV/Optical/Near-IR Globular Cluster Selection Tool

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The NGVS-IR project (Next Generation Virgo Survey – Infrared) is a contiguous near-infrared imaging survey of the Virgo cluster of galaxies. It complements the optical wide-field survey of Virgo (NGVS). The current state of NGVS-IR consists of K_s-band imaging of 4 deg^2 centered on M87, and J and K_s-band imaging of ~ 16 deg^2 covering the region between M49 and M87. In this paper, we present the observations of the central 4 deg^2 centered on Virgo's core region. The data were acquired with WIRCam on the Canada-France-Hawaii Telescope and the total integration time was 41 hours distributed in 34 contiguous tiles. A survey-specific strategy was designed to account for extended galaxies while still measuring accurate sky brightness within the survey area. The average 5σ limiting magnitude is $K_s = 24.4$ AB mag and the 50% completeness limit is $K_s = 23.75$ AB mag for point source detections, when using only images with better than $0.7''$ seeing (median seeing $0.54''$). Star clusters are marginally resolved in these image stacks, and Virgo galaxies with $\mu_{K_s} \simeq 24.4$ AB mag arcsec^{-2} are detected. Combining the K_s data with optical and ultraviolet data, we build the uiK_s color-color diagram which allows a very clean color-based selection of globular clusters in Virgo. This diagnostic plot will provide reliable globular cluster candidates for spectroscopic follow-up campaigns needed to continue the exploration of Virgo's photometric and kinematic sub-structures, and will help the design of future searches for globular clusters in extragalactic systems. We show that the new uiK_s diagram displays significantly clearer substructure in the distribution of stars, globular clusters, and galaxies than the gzK_s diagram – the NGVS+NGVS-IR-equivalent of the BzK diagram, which is widely used in cosmological surveys. Equipped with this powerful new tool, future NGVS-IR investigations based on the uiK_s diagram will address the mapping and analysis of extended structures and compact stellar systems in and around Virgo galaxies.

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Dynamical evolution - Simulations

Constraining the initial conditions of globular clusters using their radius distribution

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Studies of extragalactic globular clusters (GCs) have shown that the peak size of the GC radius distribution (RD) depends only weakly on galactic environment. We model RDs of GC populations using a simple prescription for a Hubble time of relaxation-driven evolution of cluster mass and radius. We consider a power-law cluster initial mass function (CIMF) with and without an exponential truncation, and focus in particular on a flat and a steep CIMF (power-law indices of 0 and −2, respectively). For the initial half-mass radii at birth, we adopt either Roche volume (RV) filling conditions ('filling', meaning that the ratio of half-mass to Jacobi radius is approximately $r_h/r_J \sim 0.15$) or strongly RV under-filling conditions ('under-filling', implying that initially $r_h/r_J << 0.15$). Assuming a constant orbital velocity about the galaxy centre, we find for a steep CIMF that the typical half-light radius scales with the galactocentric radius R_G as $R_G{}^{1/3}$. This weak scaling is consistent with observations, but this scenario has the (well-known) problem that too many low-mass clusters survive. A flat CIMF with 'filling' initial conditions results in the correct MF at old ages, but with too many large (massive) clusters at large R_G. An 'under-filling' GC population with a flat CIMF also results in the correct MF, and can also successfully reproduce the shape of the RD, with a peak size that is (almost) independent of R_G. In this case, the peak size depends (almost) only on the peak mass of the GC MF. The (near) universality of the GC RD is therefore because of the (near) universality of the CIMF. There are some extended GCs in the outer halo of the Milky Way that cannot be explained by this model.

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http://arxiv.org/abs/1302.3072

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Consequences of Dynamical Disruption and Mass Segregation for the Binary Frequencies of Star Clusters

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The massive (13,000−26,000 $M_\odot$), young (15−30 Myr) Large Magellanic Cloud star cluster NGC 1818 reveals an unexpected increasing binary frequency with radius for F-type stars (1.3−2.2 $M_\odot$). This is in contrast to many older star clusters that show a decreasing binary frequency with radius. We study this phenomenon with sophisticated N-body modeling, exploring a range of initial conditions, from smooth virialized density distributions to highly substructured and collapsing configurations. We find that many of these models can reproduce the cluster's observed properties, although with a modest preference for substructured initial conditions. Our models produce the observed radial trend in binary frequency through disruption of soft binaries (with semi-major axes, $a > 3000$ AU), on approximately

a crossing time ($\sim$ 5.4 Myr), preferentially in the cluster core. Mass segregation subsequently causes the binaries to sink towards the core. After roughly one initial half-mass relaxation time ($t_{rh(0)} \sim$ 340 Myr) the radial binary frequency distribution becomes bimodal, the innermost binaries having already segregated towards the core, leaving a minimum in the radial binary frequency distribution that marches outwards with time. After 4-6 $t_{rh(0)}$, the rising distribution in the halo disappears, leaving a radial distribution that rises only towards the core. Thus, both a radial binary frequency distribution that falls towards the core (as observed for NGC 1818) and one that rises towards the core (as for older star clusters) can arise naturally from the same evolutionary sequence owing to binary disruption and mass segregation in rich star clusters.

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A prescription and fast code for the long-term evolution of star clusters II. Unbalanced and core evolution

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We introduce version two of the fast star cluster evolution code *Evolve Me A Cluster of StarS* (EMACSS). The first version (Alexander & Gieles) assumed that cluster evolution is balanced for the majority of the life-cycle, meaning that the rate of energy generation in the core of the cluster equals the diffusion rate of energy by two-body relaxation, which makes the code suitable for modelling clusters in weak tidal fields. In this new version we extend the model to include an unbalanced phase of evolution to describe the pre-collapse evolution and the accompanying escape rate such that clusters in strong tidal fields can also be modelled. We also add a prescription for the evolution of the core radius and density and a related cluster concentration parameter. The model simultaneously solves a series of first-order ordinary differential equations for the rate of change of the core radius, half-mass radius and the number of member stars N. About two thousand integration steps in time are required to solve for the entire evolution of a star cluster and this number is approximately independent of N. We compare the model to the variation of these parameters following from a series of direct N-body calculations of single-mass clusters and find good agreement in the evolution of all parameters. Relevant time-scales, such as the total lifetimes and core collapse times, are reproduced with an accuracy of about 10% for clusters with various initial half-mass radii (relative to their Jacobi radii) and a range of different initial N up to N = 65536. We intend to extend this framework to include more realistic initial conditions, such as a stellar mass spectrum and mass loss from stars. The EMACSS code can be used in star cluster population studies and in models that consider the co-evolution of (globular) star clusters and large scale structures.

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The dynamical evolution of multi-planet systems in open clusters

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The majority of stars form in star clusters and many are thought to have planetary companions. We demonstrate that multi-planet systems are prone to instabilities as a result of frequent stellar encounters in these star clusters much more than single-planet systems. The cumulative effect of close and distant encounters on these planetary systems are investigated using Monte Carlo scattering experiments. We consider two types of planetary configurations orbiting Sun-like stars: (i) five Jupiter-mass planets in the semi-major axis range $1 - 42$ AU orbiting a Solar mass star, with orbits that are initially co-planar, circular, and separated by 10 mutual Hill radii, and (ii) the four gas giants of our Solar system. We find that in the equal-mass planet model, 70% of the planets with initial semi-major axes $a > 40$ AU are either ejected or have collided with the central star or another planet within the lifetime of a typical cluster, and that more than 50% of all planets with $a < 10$ AU remain bound to the system. Planets with short orbital periods are not directly affected by encountering stars. However, secular evolution of perturbed systems may result in the ejection of the innermost planets or in physical collisions of the innermost planets with the host star, up to many thousands of years after a stellar encounter. The simulations of the Solar system-like systems indicate that Saturn, Uranus and Neptune are affected by both direct interactions with encountering stars, as well as planet-planet scattering. Jupiter, on the other hand, is almost only affected by direct encounters with neighbouring stars, as its mass is too large to be substantially perturbed by the other three planets. Our results indicate that stellar encounters can account for the apparent scarcity of exoplanets in star clusters, not only for those on wide-orbit that are directly affected by stellar encounters, but also planets close to the star which can disappear long after a stellar encounter has perturbed the planetary system.

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The evolution of the global mass stellar mass function of star clusters: an analytic description

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The evolution of the global stellar mass function (MF) of star clusters is studied based on a large set of N-body simulations of clusters with a range of initial masses, initial concentrations, in circular or elliptical orbits in different tidal environments. Models with and without initial mass segregation are included. The depletion of low mass stars in initially Roche-volume (tidal) filling clusters starts typically on a time scale of the order of the core collapse time. In clusters that are initially underfilling their Roche-volume it takes longer because the clusters have to expand to their tidal radii before dynamical mass loss becomes important. We introduce the concept of the differential mass function (DMF), which describes the changes with respect to the initial mass function (IMF). We show that the evolution of the DMF can be described by a set of very simple analytic expressions that are valid for a wide range of initial cluster parameters and for different IMFs. The agreement between this

description and the models is very good, except for initially Roche-volume underfilling clusters that are severely mass segregated.

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On central black holes in ultra-compact dwarf galaxies

Steffen Mieske [1], Matthias Frank [2], Holger Baumgardt [3], plus 3 co-authors
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The dynamical mass-to-light (M/L) ratios of massive ultra-compact dwarf galaxies (UCDs) are about 50% higher than predicted by stellar population models. Here we investigate the possibility that these elevated M/L ratios are caused by a central black hole (BH), heating up the internal motion of stars. We focus on a sample of ∼50 extragalactic UCDs for which velocity dispersions and structural parameters have been measured. Using up-to-date distance moduli and a consistent treatment of aperture and seeing effects, we calculate the ratio Ψ=$(M/L)_{dyn}/(M/L)_{pop}$ between the dynamical and the stellar population M/L of UCDs. For all UCDs with $\Psi>1$ we estimate the mass of a hypothetical central BH needed to reproduce the observed integrated velocity dispersion. Massive UCDs ($M>10^7$ $M_\odot$) have an average $\Psi = 1.7 \pm 0.2$, implying notable amounts of dark mass in them. We find that, on average, central BH masses of 10−15% of the UCD mass can explain these elevated dynamical M/L ratios. The implied BH masses in UCDs range from several 10^5 $M_\odot$ to several 10^7 $M_\odot$. In the M_{BH}-Luminosity plane, UCDs are offset by about two orders of magnitude in luminosity from the relation derived for galaxies. Our findings can be interpreted such that massive UCDs originate from progenitor galaxies with masses around 10^9 $M_\odot$, and that those progenitors have SMBH occupation fractions of 60−100%. The suggested UCD progenitor masses agree with predictions from the tidal stripping scenario. Lower-mass UCDs ($M<10^7$ $M_\odot$) exhibit a bimodal distribution in Psi, suggestive of a coexistence of massive globular clusters and tidally stripped galaxies in this mass regime. Central BHs as relict tracers of tidally stripped progenitor galaxies are a plausible explanation for the elevated dynamical M/L ratios of UCDs.

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The expansion of massive young star clusters - observation meets theory

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Most stars form as part of a star cluster. The most massive clusters in the Milky Way exist in two groups - loose and compact clusters - with significantly different sizes at the end of the star formation process. After their formation both types of clusters expand up to a factor 10−20 within the first 20 Myr. Gas expulsion at the end of the star formation process is usually regarded as only possible process that can lead to such an expansion. We investigate the effect of gas expulsion by a direct comparison between numerical models and observed clusters concentrating on clusters with masses $>10^3 M_\odot$. For these clusters the initial conditions before gas expulsion, the characteristic cluster development, its dependence on cluster mass, and the star formation efficiency (SFE) are investigated. We perform N-body simulations of the cluster expansion process after gas expulsion and compare the results with observations. We find that the expansion processes of the observed loose and compact massive clusters are driven by completely different physical processes. As expected the expansion of loose massive clusters is largely driven by the gas loss due to the low SFE of ∼30%. One new revelation is that all the observed massive clusters of this group seem to have a very similar size of 1−3 pc at the onset of expansion. It is demonstrated that compact clusters have a much higher effective SFE of 60−70% and are as a result much less affected by gas expulsion. Their expansion is mainly driven by stellar ejections caused by interactions between the cluster members. The reason why ejections are so efficient in driving cluster expansion is that they occur dominantly from the cluster centre and over an extended period of time. Thus during the first 10 Myr the internal dynamics of loose and compact clusters differ fundamentally.

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Reaction of Massive Clusters to Gas Expulsion - The cluster density dependence

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The expulsion of the unconverted gas at the end of the star formation process potentially leads to the expansion of the just formed stellar cluster and membership loss. The degree of expansion and mass loss depends largely on the star formation efficiency and scales with the mass and size of the stellar group as long as stellar interactions can be neglected. We investigate under which circumstances stellar interactions between cluster members become so important that the fraction of bound stars after gas expulsion is significantly altered. The Nbody6 code is used to simulate the cluster dynamics after gas expulsion for different SFEs. Concentrating on the most massive clusters observed in the Milky Way, we test to what extend the results depend on the model, i.e. stellar mass distribution, stellar density profile etc., and the cluster parameters, such as cluster density and size.We find that stellar interactions are responsible for up to 20% mass loss in the most compact massive clusters in the Milky Way, making ejections the prime mass loss process in such systems. Even in the loosely bound OB associations stellar interactions are responsible for at least ∼5% mass loss. The main reason why the importance of encounters for massive clusters has been largely overlooked is the often used approach of a single-mass representation instead of a realistic distribution for the stellar masses. The density-dependence of the encounter-induced mass loss is shallower than expected because of the increasing importance of few-body interactions in dense clusters compared to sparse clusters where 2-body encounters dominate.

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Ultra compact dwarf galaxy formation by tidal stripping of nucleated dwarf galaxies

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Ultra Compact Dwarf Galaxies (UCDs) and dwarf galaxy nuclei have many common properties, such as internal velocity dispersions and colour-magnitude trends, suggesting tidally stripped dwarf galaxies as a possible UCD origin. However, UCDs typically have sizes more than twice as large as nuclei at the same luminosity. We use a GPU-enabled version of the particle-mesh code SUPERBOX to study the possibility of turning nucleated dwarf galaxies into UCDs by tidally stripping them in a Virgo-like galaxy cluster. We find that motion in spherical potentials, where close passages happen many times, leads to the formation of compact ($r_h \lesssim 20$ pc) star clusters/UCDs. In contrast, orbital motion where close passages happen only once or twice leads to the formation of extended objects which are large enough to account for the full range of observed UCD sizes. For such motion, we find that dwarf galaxies need close pericentre passages with distances less than 10 kpc to undergo strong enough stripping so that UCD formation is possible. As tidal stripping produces objects with similar properties to UCDs, and our estimates suggest dwarf galaxies have been destroyed in sufficient numbers to explain the observed number of UCDs in M87, we consider tidal stripping to be a likely origin of UCDs. However, comparison with cosmological simulations is needed to determine if the number and spatial distribution of UCDs formed by tidal stripping matches the observations of UCDs in galaxy clusters.

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`http://arxiv.org/abs/1305.3656`

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The role of galaxy mergers on the evolution of star clusters

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Interacting galaxies favour the formation of star clusters but are also suspected to affect their evolution through an intense and rapidly varying tidal field. Treating this complex behaviour remains out-of-reach of (semi-)analytical studies. By computing the tidal field from galactic models and including it into star-by-star N-body simulations of star clusters, we monitor the structure and mass evolution of a population of clusters in a galaxy major merger, taking the Antennae galaxies (NGC 4038/39) as a prototype. On the long time-scale ($\sim 10^9$ yr), the merger only indirectly affects the evolution of clusters by modifying their orbits in or around the galaxies: the mass-loss of clusters in the merger remnant is faster, while clusters ejected in the tidal debris survive much longer, compared to in an isolated galaxy. The tidal perturbations of the galactic collisions themselves are too short lived and not strong enough to significantly influence the structure and dissolution of realistically dense/massive star clusters.

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Miscellaneous

Stochastic stellar cluster initial mass functions: Models and impact on integrated cluster parameter determination

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Stellar clusters are regularly used to study the evolution of their host galaxy. Except for a few nearby galaxies, these studies rely on the interpretation of integrated cluster properties, especially integrated photometry observed using multiple filters (i.e. the Spectral Energy Distribution SED). To allow interpretation of such observations, we present a large set of GALEV cluster models using the realistic approach of adopting stochastically-sampled stellar IMFs. We provide models for a wide range of cluster masses ($10^3 - 2{\times}10^5 M_\odot$), metallicities ($-2.3 \leqslant$ [Fe/H] $\leqslant +0.18$ dex), foreground extinction, and 184 regularly used filters. We analyze various sets of stochastic cluster SEDs by fitting them with non-stochastic models, which is the procedure commonly used in this field. We identify caveats and quantify the fitting uncertainties associated with this standard procedure. We show that this can yield highly unreliable fitting results, especially for low-mass clusters.

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`http://data.galev.org/models/anders13/`

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Constraining Globular Cluster Formation Through Studies of Young Massive Clusters: I. A lack of ongoing star formation within young clusters

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We present a survey of 130 Galactic and extragalactic young massive clusters (YMCs, $10^4 < M_\odot < 10^8$, $10 < t/\mathrm{Myr} < 1000$) with integrated spectroscopy or resolved stellar photometry (40 presented here and 90 from the literature) and use the sample to search for evidence of ongoing star-formation within the clusters. Such episodes of secondary (or continuous) star-formation are predicted by models that attempt to explain the observed chemical and photometric anomalies observed in globular clusters as being due to the formation of a second stellar population within an existing first population. Additionally, studies that have claimed extended star-formation histories within LMC/SMC intermediate age clusters (1-2 Gyr), also imply that many young massive clusters should show ongoing star-formation. Based on visual inspection of the spectra and/or the colour-magnitude diagrams, we do not find evidence for ongoing star-formation within any of the clusters, and use this to place constraints on the above models. Models of continuous star-formation within clusters, lasting for hundreds of Myr, are ruled out at high significance (unless stellar IMF variations are invoked). Models for the (nearly instantaneous) formation of a secondary population within an existing first generation are not favoured, but are not formally discounted due to the finite sampling of age/mass-space.

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Feedback-regulated star formation: II. dual constraints on the SFE and the age spread of stars in massive clusters

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We show that the termination of the star formation process by winds from massive stars in proto-cluster forming clumps imposes dual constraints on the star formation efficiencies (SFEs) and stellar age spreads ($\Delta\tau_*$) in stellar clusters. We have considered two main classes of clump models. One class of models in one in which the core formation efficiency (CFE) per unit time and as a consequence the star formation rate (SFR) is constant in time and another class of models in which the CFE per unit time, and as a consequence the SFR, increases with time. Models with an increasing mode of star formation yield shorter age spreads (a few 0.1 Myrs) and typically higher SFEs than models in which star formation is uniform in time. We find that the former models reproduce remarkably well the SFE$-\Delta\tau_*$ values of starburst clusters such as NGC 3603 YC and Westerlund 1, while the latter describe better the star formation process in lower density environments such as in the Orion Nebula Cluster. We also show that the SFE and $\Delta\tau_*$ of massive clusters are expected to be higher in low metallicity environments. This could be tested with future large extragalactic surveys of stellar clusters. We advocate that placing a stellar cluster on the SFE-$\Delta\tau_*$ diagram is a powerful method to distinguish between different stellar clusters formation scenarios such as between generic gravitational instability of a gas cloud/clump or as the result of cloud-cloud collisions. It is also a very useful tool for testing star formation theories and numerical models versus the observations.

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`http://arxiv.org/abs/1306.6338`

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Roche volume filling of star clusters in the Milky Way

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We examine the ratios r_h/r_J of projected half-mass and Jacobi radius as well as r_t/r_J of tidal and Jacobi radius for open and globular clusters in the Milky Way using data of both observations and simulations. We applied an improved calculation of r_J for eccentric orbits of globular clusters. A sample of 236 open clusters of Piskunov et al. within the nearest kiloparsec around the Sun has been used. For the Milky Way globular clusters, data are taken from the Harris catalogue. We particularly use the subsample of 38 Milky Way globular clusters for which orbits have been integrated by Dinescu et al. We aim to quantify the differences between open and globular clusters and to understand, why they form two intrinsically distinct populations. We find under certain assumptions, or, in other words, in certain approximations, (i) that globular clusters are presently Roche volume underfilling and (ii) with at least 3σ confidence that the ratio r_h/r_J of half-mass and Jacobi radius is $3-5$ times larger at present for an average open cluster in our sample than for an average globular cluster in our sample and (iii) that a significant fraction of globular clusters may be Roche volume overfilling at pericentre with $r_t > r_J$. Another aim of this paper is to throw light on the underlying theoretical reason for the existence of the van den Bergh correlation between half-mass and galactocentric radius.

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`http://arxiv.org/abs/1212.2021`

Proceedings abstracts

Young Massive Clusters and Their Relation to Star Formation

Nate Bastian
LJMU

The formation of massive stellar clusters is intricately linked to star formation on local and global scales. All actively star forming galaxies are forming clusters, and the local initial conditions likely determine whether bound massive clusters or unbound associations are formed. Here, we focus on observed scaling relations between cluster populations and the properties of the host galaxy. In particular, we discuss the relations between the fraction of U-band light from clusters vs. their host galaxy as well as the brightest cluster vs. population size and host galaxy star formation rate (SFR). We also discuss the the fraction of stellar mass formed within bound clusters within the Galaxy, nearby dwarf galaxies, as well as starbursts and mergers. Bound clusters appear to represent ∼10% of star formation within most galaxies, although there are intriguing hints that this fraction systematically increases in galaxies with higher star formation rate surface densities. Throughout the review we highlight potential avenues for future study.

invited review to appear in "370 Years of Astronomy in Utrecht", Eds. G. Pugliese, A. de Koter, M. Wijburg, Astronomical Society of the Pacific Conference Series
http://arxiv.org/abs/1208.3403

Conferences and Announcements

Conference: Binary systems, their evolution and environments

1-5 September, 2014
Ulaan Baatar (Mongolia)
First Announcement: 1 October 2013
http://mongolia.csp.escience.cn

Scientific Rationale

More than half of all stars form part of binary or higher-order multiple systems at least temporarily during their lifetimes. Yet, the highly successful field of stellar population synthesis all but ignores the presence of large fractions of stellar multiplicity. During this conference, we aim at bringing together observers, theorists and modellers to explore the synergies among the closely related fields focusing on stellar evolution and stellar dynamics, with particular emphasis on the contributions and properties of binary and higher-order multiple systems. Although we aim at addressing the key issues in these rapidly evolving areas from a population synthesis perspective, we will pay special attention to those individual stellar species that contribute most significantly to the stellar population properties that are most uniquely related to stellar multiplicity.

In particular, the conference programme will be compiled around five main themes, i.e.:

1. Formation of stellar multiplicity: binaries, triples and higher-order multiples
2. Stellar and binary evolution across the Hertzsprung-Russell diagram (including the chemical evolution of globular clusters and their host galaxies)
3. Dynamics of binaries and higher-order multiple systems
4. Low-mass binary systems: population synthesis (SNe Ia, CVs, UV-upturn, transient events, etc.)
5. High-mass binary systems: population synthesis (LBVs, WR, blue supergiants, runaway stars, X-/gamma-ray binaries, binary- induced chemical signatures in massive stars, SNe II and SN Ib/c, spectral synthesis of starbursts, end products of massive binary evolution, etc.).

Important Dates

Deadline for Submission of Abstracts: March 1st, 2014
Oral/poster presentation notification: March 31st, 2014
Deadline for Early Bird Registration: April 1st, 2014

Second data release of the INT Photometric Hα Survey (IPHAS)

Geert Barentsen and Janet Drew
Centre for Astrophysics Research, STRI, University of Hertfordshire, Hatfield, UK

IPHAS is a 180x10 square-degree survey of the northern Galactic Plane, collecting r, i and Hα photometry down to $\sim 20^{th}$ magnitude for objects within the Galactic latitude range $-5° < b < +5°$ and longitude range $30° < l < 210°$. The first release of IPHAS data, covering roughly half the survey footprint, was made in 2008 and enabled the discovery of large samples of Galactic emission line objects. In recent months a second data release, now covering over 90 percent of the survey area, has been prepared by the survey collaboration. The new data release has been re-processed to ensure a homogeneous photometric calibration across the footprint, hence providing uniform optical magnitudes for hundreds of clusters across the Galactic plane. The data opens the door to a wide range of cluster science applications, and will be made available to the public through CDS/Vizier as soon as the accompanying paper is accepted.

See the webpage for further details: `http://www.iphas.org`

Jobs

Postdoctoral Research Appointments in Dynamical Evolution of Globular Clusters
Department of Physics, University of Surrey, Guildford UK.

The astrophysics research group of the University of Surrey has 2 vacancies for postdoctoral researchers to work on the dynamical evolution of globular clusters. The posts are part of a project funded by the European Research Council (ERC) and the P.I. is Prof. Mark Gieles. The goal of the project is to understand the origin of (Milky Way) globular clusters (GCs) by (1) using dynamical N-body simulations and (2) observations of the kinematics of Milky Way GCs. Both projects aim to use GCs to put constraints on the early phases of galaxy evolution. The successful candidates are expected to work on either one of these projects, but will have the freedom to pursue their own research program.

The first project focusses on numerical N-body simulations of GCs within realistic (time-dependent) boundary conditions set by the evolving host galaxy. The aim is to couple the physical scales of GCs and galaxies using existing (legacy) codes and follow the evolution of GCs and their debris (i.e. 'cold' stellar streams) within the cosmological context. Substantial experience with dynamical models is desirable.

The second position focusses on kinematics of orbits of stars in the outer parts of GCs. The project will use radial velocity measurements (from the Gaia-ESO survey) and study the interaction between the gravitational potential of the GC and the tidal field of the Milky Way. A strong background in the dynamics of gravitational systems, data-mining and statistics is desirable.

The astrophysics research group of the University of Surrey offers a vibrant research environment with staff expertise in the area of computational astrophysics and numerical modelling on a range of physics scales (galactic nuclei, globular clusters, galaxies and cosmology), with a strong focus on science that provides synergy with the upcoming ESA-Gaia mission and related surveys.

Applicants must have (or have submitted) a Ph.D. in astronomy or astrophysics by the time of appointment to the post. The salary scale is £29,541 to £36,298 p.a. depending on experience, plus competitive annual leave entitlement and an excellent pension scheme.

Please ensure that you specify which position you are applying for in your application.

Start date: 1st February 2014 or later by negotiation
Limit of tenure: 3 years (up to 4 years in exceptional cases).
Deadline to Apply for Job: 16 December 2013.
For applications and more information about benefits go to `http://jobs.surrey.ac.uk`

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The newly formed astrophysics research group of the University of Surrey has various PhD positions available as part of the departmental startup package and a Starting Grant of the European Research Council (ERC, PI: Prof. Mark Gieles). Details on the positions, the application procedure, and general information can be found here:
`http://www.surrey.ac.uk/physics/astrophysics/opportunities/phd_projects`
`http://www.surrey.ac.uk/physics/astrophysics`
`http://www.surrey.ac.uk`
Informal inquiries about the positions can be addressed to Prof. Mark Gieles (m.gieles@surrey.ac.uk) and/or Dr. Alessia Gualandris (a.gualandris@surrey.ac.uk)