$\mathcal{SCYON}$

The Star Clusters Young & Old Newsletter

edited by Holger Baumgardt, Ernst Paunzen and Pavel Kroupa

SCYON can be found at URL:
`http://astro.u-strasbg.fr/scyon`

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EDITORIAL

Here is the 37th issue of the SCYON newsletter. Todays edition contains 26 abstracts from refereed journals and conferences and a job advertisement for a postdoc position in Grenoble.

As usual, we would like to thank all those who sent in their contributions.

Holger Baumgardt, Ernst Paunzen and Pavel Kroupa

CONTENTS

SCYON POLICY

The SCYON Newsletter publishes abstracts from any area in astronomy which are relevant to research on star clusters. We welcome all contributions. Topics to be covered include

1. Abstracts from refereed articles
2. Abstracts from conference proceedings
3. PhD summaries
4. General announcements : Conferences, new databases, and the likes.

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SCYON will be published initially once every two months. If the number of contributions justifies monthly installments, we will move toward more frequent issues in order to keep the newsletter relatively short, manageable for us, and up-to-date.

Conference and journal abstracts can be submitted at any time either by web download, or failing this, we also accept abstracts typeset using the latest latex abstract template (available from the SCYON webpage). We much prefer contributors to use the direct download form, since it is mostly automated. Abstracts will normally appear on the website as soon as they are submitted to us. Other contributions, such as PhD summaries, should be sent to us using the LaTeX template. *Please do not submit postscript files, nor encoded abstracts as e-mail attachments.*

All abstracts/contributions will be processed, but we reserve the right to not post abstracts submitted in the wrong format or which do not compile. If you experience any sort of problems accessing the web site, or with the LaTeX template, please write to us at scyon@astro.u-strasbg.fr.

A "Call for abstracts" is sent out approximately one week before the next issue of the newsletter is finalised. This call contains the deadline for abstract submissions for that coming issue and the LaTeX abstract template.

Depending on circumstances, the editors might actively solicit contributions, usually those spotted on a preprint server, but they do not publish abstracts without the author's consent.

We implicitly encourage further dissemination of the letter to institutes and astronomers who may benefit from it.

The editors

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1. Star Forming Regions

On the kinematic evolution of young local associations and the Sco-Cen complex

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Context: Over the last decade, several groups of young (mainly low-mass) stars have been discovered in the solar neighbourhood (closer than ∼100 pc), thanks to cross-correlation between X-ray, optical spectroscopy and kinematic data. These young local associations – including an important fraction whose members are Hipparcos stars – offer insights into the star formation process in low-density environments, shed light on the substellar domain, and could have played an important role in the recent history of the local interstellar medium. Aims: To study the kinematic evolution of young local associations and their relation to other young stellar groups and structures in the local interstellar medium, thus casting new light on recent star formation processes in the solar neighbourhood. Methods: We compiled the data published in the literature for young local associations. Using a realistic Galactic potential we integrated the orbits for these associations and the Sco-Cen complex back in time. Results: Combining these data with the spatial structure of the Local Bubble and the spiral structure of the Galaxy, we propose a recent history of star formation in the solar neighbourhood. We suggest that both the Sco-Cen complex and young local associations originated as a result of the impact of the inner spiral arm shock wave against a giant molecular cloud. The core of the giant molecular cloud formed the Sco-Cen complex, and some small cloudlets in a halo around the giant molecular cloud formed young local associations several million years later. We also propose a supernova in young local associations a few million years ago as the most likely candidate to have reheated the Local Bubble to its present temperature.

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X-ray properties of protostars in the Orion Nebula

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The origin and evolution of the X-ray emission in very young stellar objects (YSOs) are not yet well understood because it is very hard to observe YSOs in the protostellar phase. We study the X-ray properties of Class 0-I objects in the Orion Nebula Cluster (ONC) and compare them with those of the more evolved Class II and III members. Using Chandra Orion Ultradeep Project (COUP) data, we study the X-ray properties of stars in different evolutionary classes: luminosities, hydrogen column densities N_H, average plasma temperatures and time variability are compared in order to understand if the interaction between the circumstellar material and the central object can influence the X-ray emission. We have assembled the deepest and most complete photometric catalog of objects in the ONC region from the UV to 8 μm using data from the HST Treasury Program, deep and almost simultaneous UBVI and JHK images taken, respectively, with WFI@2.2m ESO and ISPI@4m CTIO telescopes, and *Spitzer* IRAC imaging. We select high probability candidate Class 0-I protostars, distinguishing between those having a spectral energy distribution which rises from K up to 8 μm (Class 0-Ia) from those where the SED rises from K up to 4.5 μm and decreasing afterwards (Class 0-Ib). In addition, we select a sample of "bona fide" Class II stars and a set of Class III stars with IR emission consistent with normal photospheres.

Our principal result is that Class 0-Ia objects are significantly less luminous in X-rays, both in the total and hard bands, than the more evolved Class II stars with mass larger than 0.5 $M_\odot$; these latter show X-ray luminosities similar to those of Class 0-Ib stars. This result supports the hypothesis that the onset of X-ray emission occurs at a very early stage of star formation and is in agreement with the result found in Giardino et al. (2007). Spectral properties of Class 0-I stars are similar to those of the more evolved Class II and III objects, except for a larger absorption likely due to gas in the envelope or disk of the protostellar objects. Our data suggest that the three different classes have similar X-ray temporal variability.

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2. Galactic Open Clusters

Discovery of an open cluster with a possible physical association with a planetary nebula

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We report the discovery of a new open cluster (OC) in the Galaxy at l=167.0 deg and b=-1.0 deg. Its field includes the planetary nebula (PN) PK167-0.1. We study the possible associations of the PN/OC pairs NGC2818/NGC2818A, NGC2438/M46 (NGC2437), PK6+2.5/NGC6469, as well as of the PN PK167-0.1 with NewCluster1. The analyses are based on near-infrared colour-magnitude diagrams (CMDs) and stellar radial density profiles (RDPs). NGC6469 is located in a heavily contaminated bulge field. The CMD morphology, especially for the latter two cases, is defined with a field star decontamination algorithm applied to the 2MASS J, H, and Ks photometry. Field decontamination for the OCs NGC2818A and M46 produced better defined CMDs and more accurate cluster parameters than in the literature. Those pieces of evidence point to M46 as physically associated with the PN NGC2438. The same occurs for the OC NGC2818A and the PN NGC2818, however previous radial velocity arguments indicate that they are not associated. The OC NGC6469 does not appear to be associated with the PN PK6+2.5, which probably belongs to the bulge. Finally, the distance of the OC NewCluster1 is consistent with a physical association with the PN PK167-0.1.

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Brown dwarfs and very low mass stars in the Hyades cluster : a dynamically evolved mass function.

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We conducted a search for brown dwarfs (BDs) and very low mass (VLM) stars in the 625 Myr-old Hyades cluster in order to derive the cluster's mass function across the stellar-substellar boundary. We performed a deep (I=23, z=22.5) photometric survey over 16 sq.deg. around the cluster center, followed up with K-band photometry to measure the proper motion of candidate members, and optical and near-IR spectroscopy of probable BD and VLM members. We report the discovery of the first 2 brown dwarfs in the Hyades cluster. The 2 objects have a spectral type early-T and their optical and near-IR photometry as well as their proper motion are consistent with them being cluster members. According to models, their mass is 50 Jupiter masses at an age of 625 Myr. We also report the discovery of 3 new very low mass stellar members of the cluster, and confirm the membership of 16 others. We combine these results with a list of previously known cluster members to build the present-day mass function (PDMF) of the Hyades cluster from 50 Jupiter masses to 3Mo. We find the Hyades PDMF to be strongly deficient in very low mass objects and brown dwarfs compared to the IMF of younger open clusters such as the Pleiades. We interpret this deficiency as the result of dynamical evolution over the past few 100 Myr, i.e., the preferential evaporation of low mass cluster members due to weak gravitational encounters. We thus estimate that the Hyades cluster currently hosts about 10-15 brown dwarfs, while its initial substellar population may have amounted up to 150-200 members.

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The old open cluster NGC 2112: updated estimates of fundamental parameters based on a membership analysis

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We report on a new, wide field ($20' \times 20'$), multicolor ($UBVI$), photometric campaign in the area of the nearby old open cluster NGC 2112. At the same time, we provide medium-resolution spectroscopy of 35 (and high-resolution of additional 5) Red Giant and Turn Off stars. This material is analyzed with the aim to update the fundamental parameters of this traditionally difficult cluster, which is very sparse and suffers from heavy field star contamination. Among the 40 stars with spectra, we identified 21 *bona fide* radial velocity members which allow us to put more solid constraints on the cluster's metal abundance, long suggested to be as low as the metallicity of globulars. As indicated earlier by us on a purely photometric basis (Carraro et al. 2002), the cluster [Fe/H] abundance is slightly super-solar ([Fe/H] $=0.16\pm0.03$) and close to the Hyades value, a s inferred from a detailed abundance analysis of 3 of the 5 stars with higher resolution spectra. Abundance ratios are also marginally super solar.
Based on this result, we revise the properties of NGC 2112 using stellar models from the Padova and Yale-Yonsei groups.
For this metal abundance, we find the cluster's age, reddening, and distance values are 1.8 Gyr, 0.60 mag, and 940 pc, respectively. Both the Yale-Yonsei and Padova models predict the same values for the fundamental parameters within the errors.
Overall, NGC 2112 is a typical solar neighborhood, thin disk star cluster, sharing the same chemical properties of F-G stars and open clusters close to the Sun.
This investigation outlines the importance of a detailed membership analysis in the study of disk star clusters.

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Blue Straggler Stars in Galactic Open Clusters and the effect of field star contamination

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We investigate the distribution of Blue Straggler stars in the field of three open star clusters. The main purpose is to highlight the crucial role played by general Galactic disk fore-/back-ground field stars, which are often located in the same region of the Color Magnitude Diagram as Blue Straggler stars. We analyze photometry taken from the literature of 3 open clusters of intermediate/old age rich in Blue Straggler stars, and which are projected in the direction of the Perseus arm, and study their spatial distribution and the Color Magnitude Diagram. As expected, we find that a large portion of the Blue Straggler population in these clusters are simply young field stars belonging to the spiral arm. This result has important consequences on the theories of the formation and statistics of Blue Straggler stars in different population environments: open clusters, globular clusters or dwarf galaxies. As previously emphasized by many authors, a detailed membership analysis is mandatory before comparing the Blue Straggler population in star clusters against theoretical models. Moreover, these sequences of young field stars (blue plumes) are potentially powerful tracers of Galactic structure which require further consideration.

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The Distribution of Stellar Mass in the Pleiades

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As part of an effort to understand the origin of open clusters, we present a statistical analysis of the currently observed Pleiades. Starting with a photometric catalog of the cluster, we employ a maximum likelihood technique to determine the mass distribution of its members, including single stars and both components of binary systems. We find that the overall binary fraction for unresolved pairs is 68 percent. Extrapolating to include resolved systems, this fraction climbs to about 76 percent, significantly higher than the accepted field-star result. Both figures are sensitive to the cluster age, for which we have used the currently favored value of 125 Myr. The primary and secondary masses within binaries are correlated, in the sense that their ratios are closer to unity than under the hypothesis of random pairing. We map out the spatial variation of the cluster's projected and three-dimensional mass and number densities. Finally, we revisit the issue of mass segregation in the Pleiades. We find unambiguous evidence of segregation, and introduce a new method for quantifying it.

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The Exciting Star of the Berkeley 59/Cepheus OB4 Complex and Other Chance Variable Star Discoveries

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A study is presented regarding the nature of several variable stars sampled during a campaign of photometric monitoring from the Abbey Ridge Observatory: 3 eclipsing binaries, 2 semiregulars, a luminous Be star, and a star of uncertain classification. For one of the eclipsing systems, BD+66 1673, spectroscopic observations reveal it to be an O5 V((f))n star and the probable ionizing star of the Berkeley 59/Cep OB4 complex. An analysis of spectroscopic observations and BV photometry for Berkeley 59 members in conjunction with published observations imply a cluster age of 2 Myr, a distance of d = 883+-43 pc, and a reddening of E(B-V) =1.38+-0.02. Two of the eclipsing systems are Algol-type, but one appears to be a cataclysmic variable associated with an X-ray source. ALS 10588, a B3 IVn star associated with the Cepheid SV Vul, is of uncertain classification, although consideration is given to it being a slowly pulsating B star. The environmental context of the variables is examined using spectroscopic parallax, 2MASS photometry, and proper motion data, the latter to evaluate the membership of the variable B2 Iabe star HDE 229059 in Berkeley 87, an open cluster that could offer a unique opportunity to constrain empirically the evolutionary lineage of young massive stars. Also presented are our null results for observations of a sample of northern stars listed as Cepheid candidates in the Catalogue of Newly Suspected Variables.

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Fitting the young main-sequence; distances, ages and age spreads.

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We use several main-sequence models to derive distances (and extinctions), with statistically meaningful uncertainties for 11 star-forming-regions and young clusters. The model dependency is shown to be small, allowing us to adopt the distances derived using one model. Using these distances we have revised the age order for some of the clusters of Mayne et al (2007). The new nominal ages are: ≈ 2 Myrs for NGC6530 and the ONC, ≈ 3 Myrs for λ Orionis, NGC2264 and σ Orionis, $\approx 4-5$ Myrs for NGC2362, ≈ 13 Myrs for h and χ Per, ≈ 20 Myrs for NGC1960 and ≈ 40 Myrs for NGC2547. In cases of significantly variable extinction we have derived individual extinctions using a revised Q-method (Johnson and Morgan, 1953). These new data show that the largest remaining uncertainty in deriving an age ordering (and necessarily ages) is metallicity. We also discuss the use of a feature we term the R-C gap overlap to provide a diagnostic of **isochronal** age spreads or varying accretion histories within a given star-formation-region. Finally, recent derivations of the distance to the ONC lie in two groups. Our new more precise distance of 391^{+12}_{-9} pc allows us to decisively reject the further distance, we adopt 400 pc as a convenient value.

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3. Galactic Center Clusters

Evolution of Nuclear Star Clusters

David Merritt
RIT

Two-body relaxation times of nuclear star clusters are short enough that gravitational encounters should substantially affect their structure in 10 Gyr or less. In nuclear star clusters without massive black holes, dynamical evolution is a competition betwee n core collapse, which causes densities to increase, and heat input from the surrounding galaxy, which causes densities to decrease. The maximum extent of a nucleus that can resist expansion is derived numerically for a wide range of initial conditions; observed nuclei are shown to be compact enough to resist expansion, although there may have been an earlier generation of low-density nuclei that were dissolved. An evolutionary model for NGC 205 is presented which suggests that the nucleus of this galaxy has already undergone core collapse. Adding a massive black hole to a nucleus inhibits core collapse, and nuclear star clusters with black holes always expand, due primarily to heat input from the galaxy. The expansion rate is smaller for larger black holes due to the smaller temperature difference between galaxy and nucleus when the black hole is large. The rate of stellar tidal disruptions and its variation with time are computed for a variety of initial models. The disruption rate generally decreases with time due to the evolving nuclear density, and is lower in smaller galaxies, assuming that scaling relations derived for luminous galaxies can be extended to low luminosities.

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4. Galactic Globular Clusters

A Spitzer Space Telescope Atlas of omega Centauri: The Stellar Population, Mass Loss, and the Intracluster Medium

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We present a Spitzer Space Telescope imaging survey of the most massive Galactic globular cluster, omega Centauri, and investigate stellar mass loss at low metallicity and the intracluster medium (ICM). The survey covers approximately 3.2x the cluster half-mass radius at 3.6, 4.5, 5.8, 8, and 24 microns, resulting in a catalog of over 40,000 point-sources in the cluster. Approximately 140 cluster members ranging 1.5 dex in metallicity show a red excess at 24 microns, indicative of circumstellar dust. If all of the dusty sources are experiencing mass loss, the cumulative rate of loss is estimated at 2.9 - 4.2 x 10^{-7} solar masses per year, 63% – 66% of which is supplied by three asymptotic giant branch stars at the tip of the Red Giant Branch (RGB). There is little evidence for strong mass loss lower on the RGB. If this material had remained in the cluster center, its dust component(> 1 x 10^{-4} solar masses) would be detectable in our 24 and 70 micron images. While no dust cloud located at the center of omega Cen is apparent, we do see four regions of very faint, diffuse emission beyond two half-mass radii at 24 microns. It is unclear whether these dust clouds are foreground emission or are associated with omega Cen. In the latter case, these clouds may be the ICM in the process of escaping from the cluster.

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A Correlation between Blue Straggler and Binary Fractions in the core of Galactic Globular Clusters

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Context. Blue Stragglers Stars (BSSs) are thought to form in globular clusters by two main formation channels: i) mergers induced by stellar collisions and ii) coalescence or mass-transfer between companions in binary systems. The detailed study of the BSS properties is therefore crucial for understanding the binary evolution mechanisms, and the complex interplay between dynamics and stellar evolution in dense stellar systems. Aims. We present the first comparison between the BSS specific frequency and the binary fraction in the core of a sample of Galactic globular clusters, with the aim of investigating the relative efficiency of the two proposed formation mechanisms. Methods. We derived the frequency of BSSs in the core of thirteen low-density Galactic globular clusters by using deep ACS@HST observations and investigated its correlation with the binary fraction and various other cluster parameters. Results. We observed a correlation between the BSS specific frequency and the binary fraction. The significance of the correlation increases by including a further dependence on the cluster central velocity dispersion. Conclusions. We conclude that the unperturbed evolution of primordial binaries could be the dominant BSS formation process, at least in low-density environments.

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5. Extragalactic Clusters

Anatomy of a young massive star cluster: NGC 1569-B

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We present new H-band echelle spectra, obtained with the NIRSPEC spectrograph at Keck II, for the massive star cluster 'B' in the nearby dwarf irregular galaxy NGC 1569. From spectral synthesis and equivalent width measurements, we obtain abundances and abundance patterns. We derive an Fe abundance of [Fe/H] = -0.63 +/- 0.08, a supersolar [alpha/Fe] abundance ratio of +0.31 +/- 0.09, and an O abundance of [O/H] = -0.29 +/- 0.07. We also measure a low 12C/13C $\sim$ 5 +/- 1 isotopic ratio. Using archival imaging from the Advanced Camera for Surveys onboard the Hubble Space Telescope (HST), we construct a colour-magnitude diagram (CMD) for the cluster in which we identify about 60 red supergiant (RSG) stars, consistent with the strong RSG features seen in the H-band spectrum. The mean effective temperature of these RSGs, derived from their observed colours and weighted by their estimated H-band luminosities, is 3790 K, in excellent agreement with our spectroscopic estimate of Teff = 3800 +/- 200 K. From the CMD, we derive an age of 15-25 Myr, slightly older than previous estimates based on integrated broad-band colours. We derive a radial velocity of $< v_r >= -78 +/- 3$ km s^{-1} and a velocity dispersion of 9.6 +/- 0.3 km s^{-1}. In combination with an estimate of the half-light radius of 0.20 +/- 0.05 arcsec from the HST data, this leads to a dynamical mass of (4.4 +/- 1.1) 10^5 Msolar. The dynamical mass agrees very well with the mass predicted by simple stellar population models for a cluster of this age and luminosity, assuming a normal stellar initial mass function. The cluster core radius appears smaller at longer wavelengths, as has previously been found in other extragalactic young star clusters.

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A Survey of Star Clusters in the M31 South-West Field. UBVRI Photometry and Multi-Band Maps

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A new survey of star clusters in the South-West field of the M31 disk based on the high resolution Subaru Suprime-Cam observations is presented. The UBVRI aperture CCD photometry catalog of 285 objects (V $<$ 20.5; 169 of them identified for the first time) is provided. Each object is supplemented with multi-band color maps presented in the electronic edition of the Astrophysical Journal Supplement. Seventy seven star cluster candidates from the catalog are located in the Hubble Space Telescope archive frames.

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Photometry of Star Clusters in the M31 Galaxy. Aperture Size Effects

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(1) Inst. of Physics, Lithuania, (2) The Graduate Univ. for Advanced Studies, Japan

A study of aperture size effects on star cluster photometry in crowded fields is presented. Tests were performed on a sample of 285 star cluster candidates in the South-West field of the M31 galaxy disk, measured in the Local Group Galaxy Survey mosaic images (Massey et al. 2006). In the majority of cases the derived UBVRI photometry errors represent the accuracy of cluster colors well, however, for faint objects, residing in crowded environments, uncertainties of colors could be underestimated. Therefore, prior to deriving cluster parameters via a comparison of measured colors with SSP models, biases of colors, arising due to background crowding, must be taken into account. A comparison of our photometry data with Hubble Space Telescope observations of the clusters by Krienke and Hodge (2007) is provided.

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VLT Spectroscopy of Globular Clusters in Low Surface Brightness Dwarf Galaxies

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We present VLT/FORS2 spectroscopic observations of globular clusters (GCs) in five low surface brightness (LSB) dwarf galaxies: KK211 and KK221, which are both dwarf spheroidal satellites (dSph) of NGC 5128, dSph KK84 located close to the isolated S0 galaxy NGC 3115, and two isolated dwarf irregular (dIrr) galaxies UGC 3755 and ESO 490-17. Our sample is selected from the Sharina et al. (2005) database of Hubble Space Telescope WFPC2 photometry of GC candidates in dwarf galaxies. For objects with accurate radial velocity measurements we confirm 26 as genuine GCs out of the 27 selected candidates from our WFPC2 survey. One candidate appears to be a distant galaxy. Our measurements of the Lick absorption line indices in the spectra of confirmed GCs and the subsequent comparison with SSP model predictions show that all confirmed GCs in dSphs are old, except GC KK211-3-149 (6±2 Gyr), which we consider to be the nucleus of KK211. GCs in UGC 3755 and ESO 490-17 show a large spread in ages ranging from old objects ($t > 10$ Gyr) to clusters with ages around 1 Gyr. Most of our sample GCs have low metallicities $[Z/H] \leq -1$. Two relatively metal-rich clusters with $[Z/H] \approx -0.3$ are likely to be associated with NGC 3115. Our sample GCs show in general a complex distribution of α-element enhancement with a mean $\langle[\alpha/\mathrm{Fe}]\rangle = 0.19 \pm 0.04$ derived with the χ^2 minimization technique and 0.18 ± 0.12 dex computed with the iterative approach. These values are slightly lower than the mean $\langle[\alpha/\mathrm{Fe}]\rangle = 0.29 \pm 0.01$ for typical Milky Way GCs. We compare other abundance ratios with those of Local Group GCs and find indications for systematic differences in N and Ca abundance. The specific frequencies, S_N, of our sample galaxies are in line with the predictions of a simple mass-loss model for dwarf galaxies and compare well with S_N values found for dwarf galaxies in nearby galaxy clusters.

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A Comparison of Optical and Near-Infrared Colours of Magellanic Cloud Star Clusters with Predictions of Simple Stellar Population Models

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We present integrated JHK_s 2MASS photometry and a compilation of integrated-light optical photoelectric measurements for 84 star clusters in the Magellanic Clouds. These clusters range in age from $\approx$ 200 Myr to $>$ 10 Gyr, and have [Fe/H] values from -2.2 to -0.1 dex. We find a spread in the intrinsic colours of clusters with similar ages and metallicities, at least some of which is due to stochastic fluctuations in the number of bright stars residing in low-mass clusters. We use 54 clusters with the most reliable age and metallicity estimates as test particles to evaluate the performance of four widely used SSP models in the optical/NIR colour-colour space. All models reproduce the reddening-corrected colours of the old ($\geq$ 10 Gyr) globular clusters quite well, but model performance varies at younger ages. In order to account for the effects of stochastic fluctuations in individual clusters, we provide composite $B-V$, $B-J$, $V-J$, $V-K_s$ and $J-K_s$ colours for Magellanic Cloud clusters in several different age intervals. The accumulated mass for most composite clusters are higher than that needed to keep luminosity variations due to stochastic fluctuations below the 10% level. The colours of the composite clusters are clearly distinct in optical-NIR colour-colour space for the following intervals of age: $>$ 10 Gyr, $2-9$ Gyr, $1-2$ Gyr, and 200 Myr-1 Gyr. This suggests that a combination of optical plus NIR colours can be used to differentiate clusters of different age and metallicity.

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A Survey of Compact Star Clusters in the S-W Field of the M31 Disk. Structural Parameters. II

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The King and the EFF (Elson, Fall & Freeman 1987) analytical models are employed to determine the structural parameters of star clusters using an 1-D surface brightness profile fitting method. The structural parameters are derived and a catalogue is provided for 51 star cluster candidates from the survey of compact star clusters in the South-West field of the M31 disk performed by Kodaira et al. (2004).

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An extended star cluster at the outer edge of the spiral galaxy M33

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We report a discovery of an extended globular-like star cluster, M33-EC1, at the outer edge of the spiral galaxy M33. The distance to the cluster is 890 kpc, and it lies at a 12.5 kpc projected distance from the center of M33. Old age (> 7 Gyr) and low metallicity ([M/H] < -1.4) are estimated on the basis of isochrone fits. Color-magnitude diagrams of stars, located in the cluster's area, photometric and structural parameters of the cluster are presented. Cluster's luminosity ($M_V = -6.6$) and half-light radius ($r_h = 20.3$ pc) are comparable to those of the extended globular clusters, discovered in more luminous Local Group galaxies, the Milky Way and M31. Extended globular clusters are suspected to be remnants of accreted dwarf galaxies, and the finding of such a cluster in the late-type dwarf spiral galaxy M33 would imply a complex merging history in the past.

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6. Dynamical evolution - Simulations

Evolution of Compact-Binary Populations in Globular Clusters: A Boltzmann Study II. Introducing Stochasticity

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We continue exploration of the Boltzmann scheme started in Banerjee and Ghosh (2007, henceforth Paper I) for studying the evolution of compact-binary populations of globular clusters, introducing in this paper an explicit method for describing the inherent stochasticity of the dynamical processes of binary formation, destruction and hardening in globular clusters due to stellar encounters. We describe the fluctuations in the rates of the above stochastic processes as a "Wiener process". The Boltzmann equation then becomes a stochastic partial differential equation, the solution of which involves the use of "Ito calculus" (this use being the first, to our knowledge, in this subject), in addition to ordinary calculus. As in Paper I, we focus on the evolution of (a) the number of X-ray sources N_{XB} in globular clusters, and (b) the orbital-period distribution of the X-ray binaries, showing explicitly the fluctuations in the results due to the stochasticity in the above processes. We show that, although the details of these fluctuations differ from one "realization" to another of the stochastic processes, the general trends of the full results follow those found in the continuous-limit study of Paper I. Indeed, the average result over many such realizations is very close to the continuous-limit result, showing the value of the latter for understanding overall trends. Extending the results of Paper I, we investigate the dependence of N_{XB} found by these full calculations on two essential globular-cluster properties, namely, the star-star and star-binary encounter-rate parameters Γ and γ, which we used extensively in Paper I, and which we called Verbunt parameters. We compare our computed results with those from CHANDRA observations of galactic globular clusters, showing that the expected scaling of N_{XB} with the Verbunt parameters is in good agreement with the observed one. We indicate how more complicated, time-dependent problems can be tackled with this scheme, and also what additional features are to be incorporated into the scheme in the future.

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FROM STAR COMPLEXES TO THE FIELD: OPEN CLUSTER FAMILIES

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The currently accepted paradigm for star formation assumes that field stars are born in clusters. These are not formed in isolation but in stellar complexes born out of giant molecular clouds. In the Galactic disk, molecular clouds have distinctive orbits, which, as they disappear after star formation is complete, may seed the Galactic disk with families of young clusters. These families gradually disperse to become individual clusters and, eventually, field populations.We investigate the existence of dynamical families of open clusters in the solar neighborhood using both age- and volume-limited samples from WEBDA in the framework of scan statistics. Our analysis indicates that a significant number of known young clusters organize in groups when age, spatial distribution, and kinematics are taken into account simultaneously. We find compelling statistical evidence for the presence of at least five dynamical families of young open clusters in the Milky Way disk associated to the underlying spiral structure. The young cluster population seems to be dominated by families of 10-20 objects; they are short-lived and the likely progenitors of classical moving groups, and stellar streams. Available observational data suggests that 50%-80% of newly formed open clusters dissolve within 20 Myr of formation to become field population. The overall age distribution of open clusters shows a steep decline, $dN/d\tau \propto \tau^{\beta}$, with $\beta = -3.6 \pm 0.5$ for clusters younger than 100 Myr, although it could be dependent on the local conditions as it ranges from $\beta = -1.0 \pm 0.2$ in the direction of Puppis to $\beta = -2.8 \pm 0.5$ in Norma. Due to the high rate of destruction among young clusters, any cluster-related coherent substructure must be younger than about 30 Myr unless it is the result of dynamically induced corotation resonances within the Galactic disk or minor mergers. The characteristic timescale for stars to become part of the field stellar populations is 10-20 Myr.

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Mass segregation in young star clusters: can it be detected from the integrated properties?

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We consider the effect of mass segregation on the observable integrated properties of star clusters. The measurable properties depend on a combination of the dynamical age of the cluster and the physical age of the stars in the cluster. To investigate all possible combinations of these two quantities we propose an analytical model for the mass function of segregated star clusters that agrees with the results of N-body simulations, in which any combination can be specified. For a realistic degree of mass segregation and a fixed density profile we find with increasing age an increase in the measured core radii and a central surface brightness that decreases in all filters more rapidly than what is expected from stellar evolution alone. Within a Gyr the measured core radius increases by a factor of two and the central surface density in all filters of a segregated cluster will be overestimated by a similar factor when not taking into account mass segregation in the conversion from light to mass. We find that the $V-I$ colour of mass segregated clusters decreases with radius by about 0.1-0.2 mag, which could be observable. From recent observations of partially resolved extra-galactic clusters a decreasing half-light radius with increasing wavelength was observed, which was attributed to mass segregation. These observations can not be reproduced by our models. We find that the differences between measured radii in different filters are always smaller than 5%.

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Black holes and core expansion in massive star clusters

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We present the results from realistic N-body modelling of massive star clusters in the Magellanic Clouds. We have computed eight simulations with $N \sim 10^5$ particles; six of these were evolved for at least a Hubble time. The aim of this modelling is to examine the possibility of large-scale core expansion in massive star clusters and search for a viable dynamical origin for the radius-age trend observed for such objects in the Magellanic Clouds. We identify two physical processes which can lead to significant and prolonged cluster core expansion: mass-loss due to rapid stellar evolution in a primordially mass segregated cluster, and heating due to a retained population of stellar-mass black holes. These two processes operate over different time-scales - the former occurs only at early times and cannot drive core expansion for longer than a few hundred Myr, while the latter typically does not begin until several hundred Myr have passed but can result in core expansion lasting for many Gyr. We investigate the behaviour of these expansion mechanisms in clusters with varying degrees of primordial mass segregation and in clusters with varying black hole retention fractions. In combination, the two processes can lead to a wide variety of evolutionary paths on the radius-age plane, which fully cover the observed cluster distribution and hence define a dynamical origin for the radius-age trend in the Magellanic Clouds. We discuss the implications of core expansion for various aspects of globular cluster research, as well as the possibility of observationally inferring the presence of a population of stellar-mass black holes in a cluster.

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7. Miscellaneous

Accuracy of Star Cluster Parameters from Integrated UBVRI Photometry

D. Narbutis, A. Bridzius, R. Stonkute, V. Vansevicius
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We study the capability of the UBVRI photometric system to quantify star clusters in terms of age, metallicity, and color excess by their integrated photometry. The well known age-metallicity-extinction degeneracy was analyzed for various parameter combinations, assuming different levels of photometric accuracy. We conclude that the UBVRI photometric system enables us to estimate star cluster parameters over a wide range, if the overall photometric accuracy is better than ∼0.03 mag.

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The rotational evolution of young low mass stars

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Star-disk interaction is thought to drive the angular momentum evolution of young stars. In this review, I present the latest results obtained on the rotational properties of low mass and very low mass pre-main sequence stars. I discuss the evidence for extremely efficient angular momentum removal over the first few Myr of pre-main sequence evolution and describe recent results that support an accretion-driven braking mechanism. Angular momentum evolution models are presented and their implication for accretion disk lifetimes discussed.

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What determines the mass of the most massive star cluster in a galaxy: statistics, physics or disruption?

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In many different galactic environments the cluster initial mass function (CIMF) is well described by a power-law with index -2. This implies a linear relation between the mass of the most massive cluster (M_{max}) and the number of clusters. Assuming a constant cluster formation rate and no disruption of the most massive clusters it also means that M_{max} increases linearly with age when determining M_{max} in logarithmic age bins. We observe this increase in five out of the seven galaxies in our sample, suggesting that M_{max} is determined by the size of the sample. It also means that massive clusters are very stable against disruption, in disagreement with the mass independent disruption (MID) model presented at this conference. For the clusters in M51 and the Antennae galaxies the size-of-sample prediction breaks down around $10^6 M_\odot$, suggesting that this is a physical upper limit to the masses of star clusters in these galaxies. In this method there is a degeneracy between MID and a CIMF truncation. We show how the cluster luminosity function can serve as a tool to distinguish between the two.

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Post-doc Research Training Network CONSTELLATION: The origin of stellar masses.

A 2-year postdoctoral position is available at the Laboratoire d'Astrophysique de l'Observatoire de Grenoble (LAOG, http://www-laog.obs.ujf-grenoble.fr) in the framework of the European Commission FP6 Marie Curie Research Training Network CONSTELLATION: The origin of stellar masses. The scientific context is the search for the origin of brown dwarfs.

The successful candidate will take a significant role in a large-scale observing program aimed at searching for the origin of brown dwarfs, their physical properties, their early dynamical evolution, and their relationship to planets. He/she will be involved in the analysis of an on-going Large Program at CFHT which uses the wide-field infrared camera WIRCAM to search for the lowest-mass objects in nearby star-forming regions. The appointment is for 2 years, starting as early as summer 2008, but no later than November 30 2008. Candidates with expertise in infrared imaging and spectroscopy are encouraged to apply. Expertise in N-body simulations of low-mass populations in stellar clusters is also welcome.

Application forms, eligibility criteria, and terms of employment are to be found at:
`http://www.constellation-rtn.eu/wiki/index.php/PhD_and_Postdoctoral_Positions_Available`

The closing date for applications is March 1st, 2008.
Contact: Jerome Bouvier (jerome.bouvier@obs.ujf-grenoble.fr)