$\mathcal{SCYON}$

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`

SCYON Issue No. 45 *15 December 2009*

EDITORIAL

This is the 45th issue of the SCYON newsletter and the last one for 2009. In total we have 23 abstracts from refereed publications and conference proceedings. We also have summaries of the PhD thesis of Jonathan Downing on the evolution of compact binary populations in globular clusters, and the PhD thesis of Luca Fossati on detailed abundance analysis of early-type stars in open clusters. We finally have announcements for two conferences in June 2010, one on nuclear star clusters at ESO, Germany and a conference on binary star evolution in Greece, and a job advertisement by Gilles Chabrier for several postdoc positions in theoretical astrophysics at ENS Lyon.

We wish everybody a merry holiday season and a happy new year 2010 and thank all who sent us 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.

Concerning possible infringements to copyright laws, we understand that the authors themselves are taking responsibility for the material they send us. We make no claim whatsoever to owning the material that is posted at our url or circulated by email. The newsletter SCYON is a free service. It does not substitute for our personal opinions, nor does it reflect in any way the views of our respective institutes of affiliations.

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

SCYON Mirrors

The official Scyon mirror site in Australia is hosted at the Centre for Astrophysics & Supercomputing of the University of Swinburne by Duncan Forbes and his team :

HTTP://ASTRONOMY.SWIN.EDU.AU/SCYON/)

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1. Star Forming Regions

Near infrared imaging of the cometary globule CG12

Lauri, K. Haikala[1] **and Bo Reipurth** [2]
[1]University of Helsinki Observatory, PO Box 14, University of Helsinki, Finland
[2]Institute for Astronomy, University of Hawaii, 640 N. Aohoku Place, Hilo, HI 96720, USA

Cometary globule 12 is a relatively little investigated medium- and low mass star forming region 210 pc above the Galactic plane. NIR J, H, and Ks imaging and stellar photometry is used to analyse the stellar content and the structure of CG 12. Several new members and member candidates of the CG 12 stellar cluster were found. The new members include in particular a highly embedded source with a circumstellar disk or shell and a variable star with a circumstellar disk which forms a binary with a previously known A spectral type cluster member. The central source of the known collimated molecular outflow in CG 12 and an associated "hourglass"-shaped object due to reflected light from the source were also detected. HIRES-enhanced IRAS images are used together with SOFI J,H,Ks imaging to study the two associated IRAS point sources, 13546–3941 and 13547–3944. Two new 12 micrometer sources coinciding with NIR excess stars were detected in the direction of IRAS 13546–3941. The IRAS 13547–3944 emission at 12 and 25 micrometers originates in the Herbig AeBe star h4636n and the 60 and 100 micrometer emission from an adjacent cold source.

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For preprints, contact `lauri.haikala@helsinki.fi`
Also available from the URL `http://arxiv.org/pdf/0910.4864`

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2. Galactic Open Clusters

Not an open cluster after all: the NGC 6863 asterism in Aquila

C. Moni Bidin ([1]) R. de la Fuente Marcos ([2]) C. de la Fuente Marcos ([2]) G. Carraro ([3])
([1])Universidad de Concepcion ([2]) Suffolk University - Madrid ([3]) ESO Chile

Shortly after birth, open clusters start dissolving; gradually losing stars into the surrounding star field. The time scale for complete disintegration depends both on their initial membership and location within the Galaxy. Open clusters undergoing the terminal phase of cluster disruption or open cluster remnants (OCRs) are notoriously difficult to identify. From an observational point, a combination of low number statistics and minimal contrast against the general stellar field conspire to turn them into very challenging objects. To make the situation even worst, random samples of field stars often display features that may induce to classify them erroneously as extremely evolved open clusters. In this paper, we provide a detailed study of the stellar content and kinematics of NGC 6863, a compact group of a few stars located in Aquila and described by the Palomar Observatory Sky Survey as a non existent cluster. Nonetheless, this object has been recently classified as OCR. The aim of the present work is to either confirm or disprove its OCR status by a detailed star-by-star analysis. The analysis is performed using wide-field photometry in the UBVI pass-band, proper motions from the UCAC3 catalogue, and high resolution spectroscopy as well as results from extensive N-body calculations. The spectra of the four brightest stars in this field clearly indicate that they are part of different populations. Their radial velocities are statistically very different and their spectroscopic parallaxes are inconsistent with them being part of a single, bound stellar system. Out of the four stars, only two of them have similar metallicity. The color magnitude diagram for the field of NGC 6863 does not show any clear signature typical of actual open clusters. Consistently, spatial scan statistics confirms the absence of any statistically significant, kinematically supported over-density at the purported location of NGC 6863. Our results show that the four brightest stars commonly associated to NGC 6863 form an asterism, a group of non-physically associated stars projected together, leading to the conclusion that NGC 6863 is not a real open cluster.

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Explaining the Praesepe blue straggler HD 73666

L. Fossati[1,2] and S. Mochnacki[3] and J. Landstreet[4] and W. Weiss[1]

[1]Institut für Astronomie, Universität Wien, Türkenschanzstrasse 17, 1180 Wien, Austria, [2]Department of Physics and Astronomy, The Open University, Milton Keynes, MK7 6AA, UK, [3]Department of Astronomy & Astrophysics, University of Toronto, 50 St.George St, Rm.101, Toronto, ON, Canada M5S 3H4 [4]Department of Physics & Astronomy, University of Western Ontario, London, ON, Canada N6A 3K7

The blue straggler phenomenon is not yet well explained by current theory, although evolutionary models of star clusters require a good knowledge of it. We attempt to develop a formation scenario for HD 73666, a blue straggler member of the Praesepe cluster. We compile the known physical properties of HD 73666 found in the literature, focusing in particular on possible binarity and the abundance pattern. HD 73666 appears to be slowly rotating, have no detectable magnetic field, and have normal abundances, thereby excluding close binary evolution and mass transfer processes. There is no evidence of a hot radiation source. With the use of theoretical results on blue straggler formation present in literature, we are able to conclude that HD 73666 was probably formed by physical collision involving at least one binary system, between 5 and 350 Myr (50 Myr if the star is an intrinsic slow rotator) ago.

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For preprints, contact `l.fossati@open.ac.uk`

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How Universal are the Young Cluster Sequences? - the Cases of LMC, SMC, M83 and the Antennae

S. Pfalzner, A. Eckart
I. Physikalisches Institut University Cologne Germany

Recently a new analysis of cluster observations in the Milky Way found evidence that clustered star formation may work under tight constraints with respect to cluster size and density, implying the presence of just two sequences of young massive cluster. These two types of clusters each expand at different rates with cluster age. Here we investigate whether similar sequences exist in other nearby galaxies. We find that while for the extragalactic young stellar clusters the overall trend in the cluster-density scaling is quite comparable to the relation obtained for Galactic clusters, there are also possible difference. For the LMC and SMC clusters the densities are below the Galactic data points and/or the core radii are smaller than those of data points with comparable density. For M83 and the Antenna clusters the core radii are possibly comparable to the Galactic clusters but it is not clear whether they exhibit similar expansion speeds. These findings should serve as an incentive to perform more systematic observations and analysis to answer the question of a possible similarity between young galactic and extragalactic star clusters sequences.

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The massive star binary fraction in young open clusters - II. NGC 6611 (Eagle Nebula)

H. Sana [1,2], E. Gosset [3], C.J. Evans [4]

[1]. European Southern Observatory, Chile [2]. Universiteit van Amsterdam, The Netherlands [3]. Liege University, Belgium [4]. UK Astronomy Technology Centre, Royal Observatory Edinburgh, UK

Based on a set of over 100 medium- to high-resolution optical spectra collected from 2003 to 2009, we investigate the properties of the O-type star population in NGC 6611 in the core of the Eagle Nebula (M16). Using a much more extended data set than previously available, we revise the spectral classification and multiplicity status of the nine O-type stars in our sample. We confirm two suspected binaries and derive the first SB2 orbital solutions for two systems. We further report that two other objects are displaying a composite spectrum, suggesting possible long-period binaries. Our analysis is supported by a set of Monte-Carlo simulations, allowing us to estimate the detection biases of our campaign and showing that the latter do not affect our conclusions. The absolute minimal binary fraction in our sample is $f_{\rm min} = 0.44$ but could be as high as 0.67 if all the binary candidates are confirmed. As in NGC 6231 (see Paper I), up to 75% of the O star population in NGC 6611 are found in an O+OB system, thus implicitly excluding random pairing from a classical IMF as a process to describe the companion association in massive binaries. No statistical difference could be further identified in the binary fraction, mass-ratio and period distributions between NGC 6231 and NGC 6611, despite the difference in age and environment of the two clusters.

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The Metallicity of the Open Cluster Tombaugh 2

Sandro Villanova ([1]) Sofia Randich ([2]) Doug Geisler ([1]) Giovanni Carraro ([3]) Edgardo Costa ([4])

([1]) Universidad de Concepcion ([2]) Arcetri Observatory ([3]) ESO-Chile ([4]) Universidad de Chile

We investigate the nature of the chemical composition of the outer disc open cluster Tombaugh 2, that a recent study by Frinchaboy et al. (2008) suggested to possess an intrinsic metal abundance dispersion. We aim to investigate such claims by high resolution spectra obtained for a number of stars in the Tombaugh 2 field, together with independent UBVIc photometry. The spectra, together with input atmospheric parameters and model atmospheres, are used to determine detailed chemical abundances for a variety of elements in 13 members having good spectra. We find the mean metallicity to be [Fe/H]=-0.31+-0.02 with no evidence for an intrinsic abundance dispersion, in contrary to the recent results of Frinchaboy et al. (2008). We find Ca and Ba to be slightly enhanced while Ni and Sc are solar. The r-process element Eu was found to be enhanced, giving an average [Eu/Ba]=+0.17. The Li abundance decreases with Teff on the upper giant branch and maintains a low level for red clump stars. The mean metallicity we derive is in good agreement with that expected from the radial abundance gradient in the disc for a cluster at its Galactocentric distance. The surprising result found by Frinchaboy et al. (2008), that is the presence of 2 distinct abundance groups within the cluster, implying either a completely unique open cluster with an intrinsic metallicity spread, or a very unlikely superposition of a cold stellar stream and a very distant open cluster, is not supported by our new result.

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3. Galactic Globular Clusters

Intrinsic iron spread and a new metallicity scale for Globular Clusters

Eugenio Carretta ([1]), Angela Bragaglia ([1]), Raffaele Gratton ([2]), Valentina D'Orazi ([2]), Sara Lucatello ([2,3])

(1) INAF-Osservatorio Astronomico di Bologna, (2) INAF-Osservatorio Astronomico di Padova, (3) Excellence Cluster Universe, Garching

We have collected spectra of about 2000 red giant branch (RGB) stars in 19 Galactic globular clusters (GC) using FLAMES@VLT (about 100 star with GIRAFFE and about 10 with UVES, respectively, in each GC). These observations provide an unprecedented, precise, and homogeneous data-set of Fe abundances in GCs. We use it to study the cosmic scatter of iron and find that, as far as Fe is concerned, most GCs can still be considered mono-metallic, since the upper limit to the scatter in iron is less than 0.05 dex, meaning that the degree of homogeneity is better than 12%. The scatter in Fe we find seems to have a dependence on luminosity, possibly due to the well-known inadequacies of stellar atmospheres for upper-RGB stars and/or to intrinsic variability. It also seems to be correlated with cluster properties, like the mass, indicating a larger scatter in more massive GCs which is likely a (small) true intrinsic scatter. The 19 GCs, covering the metallicity range of the bulk of Galactic GCs, define an accurate and updated metallicity scale. We provide transformation equations for a few existing scales. We also provide new values of [Fe/H], on our scale, for all GCs in the Harris' catalogue.

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Na-O anticorrelation and HB. VIII. Proton-capture elements and metallicities in 17 globular clusters from UVES spectra

Carretta, E.; Bragaglia, A.; Gratton, R.; Lucatello, S.
INAF-Osservatorio Astronomico di Bologna, INAF-Osservatorio Astronomico di Padova

(Carretta et al. 2009b, A&A, 505, 139) We present homogeneous abundances for Fe and some of the elements involved in the proton-capture reactions (O, Na, Mg, Al, and Si) for 202 red giants in 17 Galactic globular clusters (GCs) from the analysis of high resolution UVES spectra obtained with FLAMES@ESO-VLT2. Our programme clusters span almost the whole range in metallicity of GCs and were selected to sample the widest range of global parameters (HB morphology, masses, concentration, etc). Here we focus on the discussion of the Na-O and Mg-Al anticorrelations and related issues. Our study finds clear Na and O star-to-star abundance variations in all GCs. Variations in Al are present in all but a few GCs. Finally, a spread in abundances of Mg and Si are also present in a few clusters. Mg is slightly less overabundant and Si slightly more overabundant in the most Al-rich stars. The correlation between Si and Al abundances is a signature of production of 28Si leaking from the Mg-Al cycle in a few clusters. The cross sections required for the proper reactions to take over in the cycle point to temperatures in excess of about 65 MK for the favoured site of production. We used a dilution model to infer the total range of Al abundances starting from the Al abundances in the UVES spectra, and the Na abundance distributions found from analysis of the much larger set of stars for which GIRAFFE spectra were available. We found that the maximum amount of additional Al produced by first generation polluters contributing to the composition of the second generation stars in each cluster is closely correlated with the same combination of metallicity and cluster luminosity that reproduced the minimum O abundances found from GIRAFFE spectra. We then suggest that the high temperatures required for the Mg-Al cycle are only reached in the most massive and most metal-poor polluters.

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Na-O Anticorrelation and HB. VII. The chemical composition of first and second-generation stars in 15 globular clusters from GIRAFFE spectra Authors:

E. Carretta, A. Bragaglia, R.G. Gratton, S. Lucatello, G. Catanzaro, F. Leone, M. Bellazzini, R. Claudi, V. D'Orazi, Y. Momany, S. Ortolani, E. Pancino, G. Piotto, A. Recio-Blanco, E. Sabbi

(Carretta et al. 2009a, A&A 505, 117) We present abundances of Fe, Na, and O for 1409 red giant stars in 15 galactic globular clusters, derived from the homogeneous analysis of high resolution FLAMES/GIRAFFE spectra. Combining the present data with previous results, we obtained a total sample of 1958 stars in 19 clusters, the largest and most homogeneous database of this kind to date. Our GCs have [Fe/H] from -2.4 to -0.4, with a wide variety of global parameters (morphology of the horizontal branch, mass, concentration, etc). For all clusters we find the Na-O anticorrelation, the classical signature of proton-capture reactions in H-burning at high temperature in a previous generation of more massive stars, now extinct. Using quantitative criteria (from the morphology and extension of the Na-O anticorrelation), we can define 3 components of the stellar population in GCs: a primordial component (P) of first-generation stars, and 2 components of second-generation stars (intermediate I and extreme E populations from their different chemical composition). The P component is present in all GCs, and its fraction is almost constant at about one third. The I component represents the bulk of the cluster population. The E component is not present in all GCs, and it is more conspicuous in some (but not in all) of the most massive ones. We discuss the fractions and spatial distributions of these components in our sample and in two additional clusters (M3 and M13) from the literature. We also find that the slope of the anti-correlation (defined by the minimum O and maximum Na abundances) changes from cluster-to-cluster, a change that is represented well by a bilinear relation on cluster metallicity and luminosity. This second dependence suggests a correlation between average mass of polluters and cluster mass.

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The ACS Survey of Galactic Globular Clusters. IX. Horizontal Branch Morphology and the Second Parameter Phenomenon

Aaron Dotter, Ata Sarajedini, Jay Anderson, Antonio Aparicio, Luigi R. Bedin, Brian Chaboyer, Steven Majewski, A. Marn-Franch, Antonino Milone, Nathaniel Paust, Giampaolo Piotto, I. Neill Reid, Alfred Rosenberg, Michael Siegel

University of Victoria, University of Florida, STScI, Instituto de Astrofisica de Canarias, STScI, Dartmouth College, University of Virginia, Instituto de Astrofisica de Canarias, Universita di Padova, STScI, Universita di Padova, STScI, Instituto de Astrofisica de Canarias, Penn State University

The horizontal branch (HB) morphology of globular clusters (GCs) is most strongly influenced by metallicity. The second parameter phenomenon acknowledges that metallicity alone is not enough to describe the HB morphology of all GCs. In particular, the outer Galactic halo contains GCs with redder HBs at a given metallicity than are found inside the Solar circle. Thus, at least a second parameter is required to characterize HB morphology. Here we analyze the median color difference between the HB and the red giant branch (RGB), d(V-I), measured from HST ACS photometry of 60 GCs within ∼20 kpc of the Galactic Center. Analysis of this homogeneous data set reveals that, after the influence of metallicity has been removed, the correlation between d(V-I) and age is stronger than that of any other parameter considered. Expanding the sample to include HST photometry of the 6 most distant Galactic GCs lends additional support to the correlation between d(V-I) and age. This result is robust with respect to the adopted metallicity scale and the method of age determination, but must bear the caveat that high quality, detailed abundance information is not available for a significant fraction of the sample. When a subset of GCs with similar metallicities and ages are considered, a correlation between d(V-I) and central luminosity density is exposed. With respect to the existence of GCs with anomalously red HBs at a given metallicity, we conclude that age is the second parameter and central density is most likely the third. Important problems related to HB morphology in GCs, notably multi-modal distributions and faint blue tails, remain to be explained.

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4. Galactic Center Clusters

Testing Properties of the Galactic Center Black Hole Using Stellar Orbits

David Merritt, Tal Alexander, Seppo Mikkola, Clifford M. Will
Rochester Institute of Technology, Weizmann Institute of Science, Tuorla Observatory, Washington University

The spin and quadrupole moment of the supermassive black hole at the Galactic center can in principle be measured via astrometric monitoring of stars orbiting at milliparsec (mpc) distances, allowing tests of general relativistic "no-hair" theorems (Will 2008). One complicating factor is the presence of perturbations from other stars, which may induce orbital precession of the same order of magnitude as that due to general relativistic effects. The expected number of stars in this region is small enough that full N-body simulations can be carried out. We present the results of a comprehensive set of such simulations, which include a post-Newtonian treatment of spin-orbit effects. A number of possible models for the distribution of stars and stellar remnants are considered. We find that stellar perturbations are likely to obscure the signal due to frame-dragging for stars beyond $\sim$0.5 mpc from the black hole, while measurement of the quadrupole moment is likely to require observation of stars inside $\sim$0.2 mpc. A high fraction of stellar remnants, e.g. 10-Solar-mass black holes, in this region would make tests of GR problematic at all radii. We discuss the possibility of separating the effects of stellar perturbations from those due to GR.

To appear in : Physical Review
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Constraining the initial mass function of stars in the Galactic Centre

Ulf Löckmann, Holger Baumgardt and Pavel Kroupa

Monthly Notices of the Royal Astronomical Society

Here we discuss the question whether the extreme circumstances in the centre of the Milky Way may be the reason for a significant variation of the IMF. By means of stellar evolution models using different codes we show that the observed luminosity in the central parsec is too high to be explained by a long-standing top-heavy IMF, considering the limited amount of mass inferred from stellar kinematics in this region. In contrast, continuous star formation over the Galaxy's lifetime following a canonical IMF results in a mass-to-light ratio and a total mass of stellar black holes (SBHs) consistent with the observations. Furthermore, these SBHs migrate towards the centre due to dynamical friction, turning the cusp of visible stars into a core as observed in the Galactic Centre. For the first time here we explain the luminosity and dynamical mass of the central cluster and both the presence and extent of the observed core, since the number of SBHs expected from a canonical IMF is just enough to make up for the missing luminous mass. We conclude that the Galactic Centre is consistent with the canonical IMF and do not suggest a systematic variation as a result of the region's properties such as high density, metallicity, strong tidal field etc.

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5. Extragalactic Clusters

A Hubble Space Telescope/WFPC2 Survey of Bright Young Clusters in M31. III. Structural Parameters

P. Barmby, S. Perina, M. Bellazzini, J.G. Cohen, P.W. Hodge, J.P. Huchra, M. Kissler-Patig, T.H. Puzia, J. Strader

U. Western Ontario, OA Bologna, Caltech, U. Washington, Harvard-Smithsonian CfA, ESO, Herzberg Inst. for Astrophysics

Surface brightness profiles for 23 M31 star clusters were measured using images from the Wide Field Planetary Camera 2 on the Hubble Space Telescope, and fitted to two types of models to determine the clusters' structural properties. The clusters are primarily young (∼1e8 yr) and massive (∼1e4.5 $M_\odot$), with median half-light radius 7 pc and dissolution times of a few Gyr. The properties of the M31 clusters are comparable to those of clusters of similar age in the Magellanic Clouds. Simulated star clusters are used to derive a conversion from statistical measures of cluster size to half-light radius so that the extragalactic clusters can be compared to young massive clusters in the Milky Way. All three sets of star clusters fall approximately on the same age-size relation. The young M31 clusters are expected to dissolve within a few Gyr and will not survive to become old, globular clusters. However, they do appear to follow the same fundamental plane (FP) relations as old clusters; if confirmed with velocity dispersion measurements, this would be a strong indication that the star cluster FP reflects universal cluster formation conditions.

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The M31 globular cluster system: *ugriz* and K-band photometry and structural parameters

Mark B. Peacock, Thomas J. Maccarone, Christian Knigge, Arunav Kundu, Christopher Z. Waters, Stephen E. Zepf, David R. Zurek

We present an updated catalogue of M31 globular clusters (GCs) based on images from the Wide Field CAMera (WFCAM) on the UK Infrared Telescope and from the Sloan Digital Sky Survey (SDSS). Our catalogue includes new, self-consistent *ugriz* and K-band photometry of these clusters. We discuss the difficulty of obtaining accurate photometry of clusters projected against M31 due to small scale background structure in the galaxy. We consider the effect of this on the accuracy of our photometry and provide realistic photometric error estimates. We investigate possible contamination in the current M31 GC catalogues using the excellent spatial resolution of these WFCAM images combined with the SDSS multicolour photometry. We identify a large population of clusters with very blue colours. Most of these have recently been proposed by other work as young clusters. We distinguish between these, and old clusters, in the final classifications. Our final catalogue includes 416 old clusters, 156 young clusters and 373 candidate clusters. We also investigate the structure of M31's old GCs using previously published King model fits to these WFCAM images. We demonstrate that the structure and colours of M31's old GC system are similar to those of the Milky Way. One GC (B383) is found to be significantly brighter in previous observations than observed here. We investigate all of the previous photometry of this GC and suggest that this variability appears to be genuine and short lived. We propose that the large increase in its luminosity my have been due to a classical nova in the GC at the time of the previous observations in 1989.

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Also available from the URL http://www.astro.soton.ac.uk/∼m.b.peacock/m31gc.html
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6. Dynamical evolution - Simulations

On the velocity dispersion of young star clusters: super-virial or binaries?

M. Gieles ([1]), H. Sana ([1,2]), S.F. Portegies Zwart ([3])
([1]) ESO ([2]) Amsterdam ([3]) Leiden

Many young extra-galactic clusters have a measured velocity dispersion that is too high for the mass derived from their age and total luminosity, which has led to the suggestion that they are not in virial equilibrium. Most of these clusters are confined to a narrow age range centred around 10 Myr because of observational constraints. At this age the cluster light is dominated by luminous evolved stars, such as red supergiants, with initial masses of ∼13-22 $M_\odot$ for which (primordial) binarity is high. In this study we investigate to what extent the observed excess velocity dispersion is the result of the orbital motions of binaries. We demonstrate that estimates for the dynamical mass of young star clusters, derived from the observed velocity dispersion, exceed the photometric mass by up-to a factor of 10 and are consistent with a constant offset in the square of the velocity dispersion. This can be reproduced by models of virialised star clusters hosting a massive star population of which ∼25 is in binaries, with typical mass ratios of ∼0.6 and periods of ∼1000 days. We conclude that binaries play a pivotal role in deriving the dynamical masses of young (∼10 Myr) moderately massive and compact (<1e5 Msun; > 1 pc) star clusters.

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Stellar-mass black holes in star clusters: implications for gravitational wave radiation

Sambaran Banerjee, Holger Baumgardt and Pavel Kroupa
AIfA, University of Bonn

We study the dynamics of stellar-mass black holes (BH) in star clusters with particular attention to the formation of BH-BH binaries, which are interesting as sources of gravitational waves (GW). We examine the properties of these BH-BH binaries through direct N-body simulations of star clusters using the GPU-enabled NBODY6 code. We perform simulations of N 105 Plummer clusters of low-mass stars with an initial population of BHs. Additionally, we do several calculations of star clusters confined within a reflective boundary mimicking only the core of a massive cluster. We find that stellar-mass BHs with masses 10 solar mass segregate rapidly into the cluster core and form a sub-cluster of BHs within typically 0.2 - 0.5 pc radius, which is dense enough to form BH-BH binaries through 3-body encounters. While most BH binaries are ejected from the cluster by recoils received during super-elastic encounters with the single BHs, few of them harden sufficiently so that they can merge via GW emission within the cluster. We find that for clusters with $N > 5 \cdot 10^4$, typically 1 - 2 BH-BH mergers occur within them during the first 4 Gyr of evolution. Also for each of these clusters, there are a few escaping BH binaries that can merge within a Hubble time, most of the merger times being within a few Gyr. These results indicate that intermediate-age massive clusters constitute the most important class of candidates for producing dynamical BH-BH mergers. Old globular clusters cannot contribute significantly to the present-day BH-BH merger rate since most of the mergers from them would have occurred earlier. In contrast, young massive clusters are too young to produce significant number of BH-BH mergers. Our results imply significant BH-BH merger detection rates for the proposed "Advanced LIGO" GW detector.

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For preprints, contact `holger@astro.uni-bonn.de`
Also available from the URL `http://de.arxiv.org/abs/0910.3954`
or by anonymous ftp at `ftp://`

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The Orbital Decay of Embedded Binary Stars

Steven Stahler
Astronomy Dept. U. of California Berkeley, CA 94720

Young binaries within dense molecular clouds are subject to dynamical friction from ambient gas. Consequently, their orbits decay, with both the separation and period decreasing in time. A simple analytic expression is derived for this braking torque. The derivation utilizes the fact that each binary acts as a quadrupolar source of acoustic waves. The acoustic disturbance has the morphology of a two-armed spiral and carries off angular momentum. From the expression for the braking torque, the binary orbital evolution is also determined analytically. This type of merger may help explain the origin of high-mass stars. If infrared dark clouds, with peak densities up to 10^7 cm^{-3}, contain low-mass binaries, those with separations less than 100 AU merge within about 10^5 yr. During the last few thousand years of the process, the rate of mechanical energy deposition in the gas exceeds the stars' radiative luminosity. Successive mergers may lead to the massive star formation believed to occur in these clouds.

Accepted by : Monthly Notices of the Royal Astronomical Society
For preprints, contact SStahler@astro.berkeley.edu
Also available from the URL http://arxiv.org/abs/0911.1177
or by anonymous ftp at

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Tidal disruption, global mass function and structural parameters evolution in star clusters

Michele Trenti (1), Enrico Vesperini (2), and Mario Pasquato (3)
(1) Colorado, (2) Drexel, (3) Pisa

We present a unified picture for the evolution of star clusters on the two-body relaxation timescale. We use direct N-body simulations of star clusters in a galactic tidal field starting from different multi-mass King models, up to 10% of primordial binaries and up to N(tot) = 65536 particles. An additional run also includes a central Intermediate Mass Black Hole. We find that for the broad range of initial conditions we have studied the stellar mass function of these systems presents a universal evolution which depends only on the fractional mass loss. The structure of the system, as measured by the core to half mass radius ratio, also evolves toward a universal state, which is set by the efficiency of heating on the visible population of stars induced by dynamical interactions in the core of the system. Interactions with dark remnants are dominant over the heating induced by a moderate population of primordial binaries (3-5%), especially under the assumption that most of the neutron stars and black holes are retained in the system. All our models without primordial binaries undergo a deep gravothermal collapse in the radial mass profile. However their projected light distribution can be well fitted by medium concentration King models (with parameter W0 $\sim$ 8), even though there tends to be an excess over the best fit for the innermost points of the surface brightness. This excess is consistent with a shallow cusp in the surface brightness ($\mu(R) \sim R^{-\nu}$ with $\nu \sim$ 0.4-0.7), like it has been observed for many globular clusters from high-resolution HST imaging. Classification of core-collapsed globular clusters based on their surface brightness profile is likely to fail in systems that have already bounced back to lower concentrations.

Accepted by : Astrophysical Journal
For preprints, contact `trenti@colorado.edu`
Also available from the URL `http://adsabs.harvard.edu/abs/2009arXiv0911.3394T`

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7. Miscellaneous

A revolution in star cluster research: setting the scene

Richard de Grijs
Kavli Institute for Astronomy and Astrophysics, Peking University, China; University of Sheffield, UK

Star clusters and their stellar populations play a significant role in the context of galaxy evolution, across space (from local to high redshift) and time (from currently forming to fossil remnants). We are now within reach of answering a number of fundamental questions that will have a significant impact on our understanding of key open issues in contemporary astrophysics, ranging from the formation, assembly and evolution of galaxies to the details of the star-formation process. Our improved understanding of the physics driving star cluster formation and evolution has led to the emergence of crucial new open questions that will most likely be tackled in a systematic way in the next decade.

To appear in: Phil. Trans. R. Soc. A., vol. 368 (18 January 2010)
Other useful information not covered in the fields above ...
For preprints, contact grijs@kiaa.pku.edu.cn
Also available from the URL http://arxiv.org/abs/0911.0778

Chemical evolution of star clusters

Jacco Th. van Loon
Lennard-Jones Laboratories, Keele University, ST5 5BG, UK

I discuss the chemical evolution of star clusters, with emphasis on old globular clusters, in relation to their formation histories. Globular clusters clearly formed in a complex fashion, under markedly different conditions from any younger clusters presently known. Those special conditions must be linked to the early formation epoch of the Galaxy and must not have occurred since. While a link to the formation of globular clusters in dwarf galaxies has been suggested, present-day dwarf galaxies are not representative of the gravitational potential wells within which the globular clusters formed. Instead, a formation deep within the proto-Galaxy or within dark-matter minihaloes might be favoured. Not all globular clusters may have formed and evolved similarly. In particular, we may need to distinguish Galactic halo from Galactic bulge clusters.

To appear in : Invited review. Chapter 6 in a special issue of Phil. Trans. Royal Soc. A: "Star clusters as tracers of galactic star-formation histories", ed. R. de Grijs. (Fully peer reviewed.)
For preprints, contact `jacco@astro.keele.ac.uk`
Also available from the URL `http://arxiv.org/abs/0911.0792`
or by anonymous ftp at

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Globular clusters as laboratories for stellar evolution

Márcio Catelan ([1]), Aldo A. R. Valcarce ([1]), Allen V. Sweigart ([2])
([1]) PUC-Chile ([2]) NASA-GSFC

Globular clusters have long been considered the closest approximation to a physicist's laboratory in astrophysics, and as such a near-ideal laboratory for (low-mass) stellar evolution. However, recent observations have cast a shadow on this long-standing paradigm, suggesting the presence of multiple populations with widely different abundance patterns, and – crucially – with widely different helium abundances as well. In this review we discuss which features of the Hertzsprung-Russel diagram may be used as helium abundance indicators, and present an overview of available constraints on the helium abundance in globular clusters.

To appear in : Proceedings of IAU Symp. 266 (ed. R. de Grijs & J. R. D. Lepine)
For preprints, contact `mcatelan@astro.puc.cl`
Also available from the URL `http://arxiv.org/abs/0910.1367`
or by anonymous ftp at

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The structures of embedded clusters

S. Schmeja
Zentrum für Astronomie der Universität Heidelberg

Stars are usually formed in clusters in the dense cores of molecular clouds. These embedded clusters show a wide variety of morphologies from hierarchical clusters with substructure to centrally condensed ones. Often they are elongated and surrounded by a low-density stellar halo. The structure of an embedded cluster, i.e. the spatial distribution of its members, seems to be linked to the complex structure of the parental molecular cloud and holds important clues about the formation mechanism and the initial conditions, as well as about the subsequent evolution of the cluster.

To appear in the Proceedings of the International Workshop on Interstellar Matter and Star Formation - A Multi-Wavelength Perspective, Bulletin of the Astronomical Society of India, in press; Invited review talk
For preprints, contact `sschmeja@ita.uni-heidelberg.de`
Also available from the URL `http://arxiv.org/abs/0911.1865`

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Study of the Helium Enrichment in Globular Clusters

Aldo A. R. Valcarce, Márcio Catelan
PUC-Chile

Globular clusters (GCs) are spheroidal concentrations typically containing of the order of 10^5 to 10^6, predominantly old, stars. Historically, they have been considered as the closest counterparts of the idealized concept of "simple stellar populations." However, some recent observations suggest than, at least in some GCs, some stars are present that have been formed with material processed by a previous generation of stars. In this sense, it has also been suggested that such material might be enriched in helium, and that blue horizontal branch stars in some GCs should accordingly be the natural progeny of such helium-enhanced stars. In this contribution we show that, at least in the case of M3 (NGC 5272), the suggested level of helium enrichment is not supported by the available, high-precision observations.

To appear in : IAU Symp. 262 (ed. G. Bruzual & S. Charlot)
For preprints, contact `avalcarc@astro.puc.cl`
Also available from the URL `http://arxiv.org/abs/0910.1366`
or by anonymous ftp at

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Compact Binary Populations in Globular Clusters and Prospects for Gravitational Wave Detection

J. M. B. Downing[1,2]

[1]Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Mönchhofstraße 12-14, D-69120, Heidelberg, Germany

[2]International Max Planck Research School for Astonomy and Cosmic Physics at the University of Heidelberg

The inspiral and merger of compact binary stars will be major detection events for interferometric gravitational wave observatories. These observatories operate most effectively by comparing their output to template waveforms. In order to make these templates the physical parameters of the source population must be understood. Compact binaries in the galactic field have been investigated using population synthesis models but in dense stellar environments interactions can alter the binary population and may enhance the merger rate.

I study compact binaries in star clusters using a Monte Carlo model for the dynamics. I find that the black hole population interacts strongly, leading to an enhancement in both the number of black hole binaries and the black hole binary merger rate. Due to the high interaction rate the majority of black hole binaries are ejected and thus the mergers occur in the galactic field. I find a promising rate of $1 - 100$ detections per year for the next generation of ground-based gravitational wave detectors and two possible sources for space-based detectors, both highly eccentric. I conclude that star clusters must be taken into account in order to predict accurate event rates for gravitational wave detectors.

PhD Thesis, November 18, 2009, University of Heidelberg, Supervisor: Prof. Dr. Rainer Spurzem

For preprints, contact `downin@ari.uni-heidelberg.de`

Also available from the URL `http://www.ub.uni-heidelberg.de/archiv/10079/`

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A detailed abundance analysis of early-type stars in open clusters: constraints to diffusion models

L. Fossati[1]

[1]Institut für Astronomie, Universität Wien, Türkenschanzstrasse 17, 1180 Wien, Austria

In stellar astrophysics, the study of the atmospheres of early-type stars plays a very special role. The atmospheres of these stars display a variety of different phenomena, such as the presence of large magnetic fields, strong surface convection, pulsation, diffusion of chemical elements. To fully understand the actual role of all these physical phenomena, it is important to seek constraints from the observations, in particular to perform a detailed study of a large number of stars of different ages and peculiarity types.

Open cluster stars are particularly interesting for two reasons: 1) it is possible to assume that all cluster members have approximately the same original chemical composition and age; 2) the age of stars belonging to open clusters can be determined with much higher accuracy than for field stars.

Using advanced available instrumentation (including FLAMES of the ESO VLT) I obtained high-quality spectra of a large number of early-type stars in ten open clusters, uniformly distributed in age. Here I present the results obtained for the stars observed in two clusters (NGC 5460 and Praesepe), searching for correlations between abundances and stellar parameters and to provide constraints to the models of diffusion theory.

Parameter determination and LTE abundance analysis were performed with new generation model atmosphere and synthesis codes, taking into account different spectroscopic parameter indicators. A rigorous treatment of the abundance uncertainties was performed.

The sample is composed of 54 chemically normal early-type stars, three hot He-weak stars and nine Am stars. The original main contribution of this work is the finding that the abundance of several elements increases with temperature between 7000 K and 10500 K and decreases from 10500 K to 13000 K. No correlation between abundance and $v \sin i$ was found for chemically normal stars, while I found a strong correlation between the peculiarity of Am stars and $v \sin i$, in particular that chemical peculiarity decreases with $v \sin i$.

PhD Thesis defended on June 30th, 2009 at the University of Vienna and supervised by Prof. W. Weiss and Dr. S. Bagnulo.

For preprints, contact l.fossati@open.ac.uk

First Announcement for the ESO workshop:

Central Massive Objects: The Stellar Nuclei-Black Hole Connection

22-25 June 2010

ESO Headquarters, Garching, Germany

`http://www.eso.org/sci/meetings/cmo2010`

An ESO workshop for observers and theorists to discuss recent progress in our understanding of the formation and evolution of black holes and star clusters in the centres of galaxies and their connection to each other.

Scientific Rationale:

The centers of massive galaxies are special in many ways, not the least because all of them are believed to host supermassive black holes. Since the discovery of key relations linking the mass of the central dark object with the large scale properties of the dynamically hot galactic component, it has become clear that the growth of the central black hole is intimately connected to the evolution of its host galaxy. However, for lower mass galaxies, the situation is much less clear. These galaxies, spanning a large range of Hubble types, typically host nuclear clusters of a few 10^6- 10^7 solar masses. The presence of black holes and their relation to these nuclear clusters remains largely unknown.

Recent studies have shown that nuclear cluster masses are coupled to the mass of their host galaxy, following a relation similar as for supermassive black holes, suggesting both types of central massive objects (CMOs) are closely related. Although nuclear clusters are more than the low-mass analogs of supermassive black holes, all CMOs very probably share some basic ingredients in their formation processes.

This workshop aims at bringing together a broad international audience in the combined field of galaxy nuclei, super-massive black holes, nuclear star clusters, to confront state-of-the art observations with cutting-edge models.

The key scientific questions for this workshop are:

- What is the evolutionary/causal connection between nuclear clusters and black holes?
- Are intermediate mass black holes formed in nuclear clusters/globular clusters?
- Where do we stand observationally for black holes, nuclear clusters and intermediate mass black holes?
- What can the Galactic Centre tell us about the nuclear cluster-black hole connection?
- How do the central massive objects relate to the host galaxies?
- What do theoretical models tell us about star formation in the extreme gravitational potential near the black hole and under the extreme stellar densities in galactic centers?
- What do theoretical models tell us about dynamics, evolution and migration of nuclear star clusters in galaxy centres?
- Do we understand the feeding of the central pc? How are nuclear clusters replenished with fresh gas?

Registration:

The registration deadline is March 22, 2010. Attendance at the workshop will be limited to 100 participants, so those wishing to attend should register early.

For further information and registration, please see:
`http://www.eso.org/sci/meetings/cmo2010/registration.html`

OFFICIAL ANNOUNCEMENT of an INTERNATIONAL CONFERENCE on:

BINARY STAR EVOLUTION: MASS LOSS, ACCRETION, and MERGERS

in Celebration of Ron Webbink's 65th Birthday

on Mykonos, Greece – June 22 - 25, 2010

This International Conference will be held on the occasion of Ron Webbink's 65th birthday, which also coincides with Peter Eggleton's and Ed van den Heuvel's 70th birthday. It is hard to resist such a wonderful opportunity for a triple celebration! The main scientific themes of the meeting will cover interacting binaries of all kinds, in galactic fields and dense clusters some with compact objects as sources across the electromagnetic and gravitational-wave spectra.

SCIENCE TOPICS & REQUEST FOR TALK PROPOSALS

We invite all interested, potential participants to send us brief suggestion(s) (a couple of sentences) for presentations they would like to give on results that generally connect to any of the prospective topics from the following list:

- Mass and Angular Momentum Transfer & Loss
- Physics of Common Envelope Evolution
- Contact Binaries
- Collisions/Mergers
- Binaries in Clusters
- Cataclysmic Variables & Symbiotic Stars
- X-ray Binaries
- Binary and Millisecond Pulsars
- Binary Supernova Progenitors
- Gravitational Wave Sources

We particularly invite presentations of recent, exciting results or suggestions for reviews of specific (sub-)areas of interest. The scientific program will comprise 10 sessions (two morning and one late afternoon) over 4 days with a half day free for excursions. Please send your suggestions to: w-finney@northwestern.edu by January 4, 2010.

CONFERENCE HOTEL AND ACCOMMODATIONS

Mykonos is one of the most beautiful islands in Greece. It has preserved its unique architectural character, crystal clear waters, iconic bays and sandy beaches, despite its popularity. The end of June is one of the best times to visit Greece, before the high traffic of mid-July to August. Our conference will be held at one of the best resort hotels on Mykonos, Greece:

Saint John hotel, http://www.saintjohn.gr/ [www.saintjohn.gr] -

It is located in the bay of Agios Ioannis, one of the best beaches on the island, and just across from the island of Delos. A set of rooms has been reserved at the hotel (see http://www.saintjohn.gr/mykonos-accommodation-rooms.php) [www.saintjohn.gr] for conference participants at rates much lower than their regular prices for the time of the conference.

Rates are per room (2 occupants) per night and include breakfast and all taxes: Garden View: 160 euros Executive Sea View: 195 euros

You will be able to submit your room reservations directly to the hotel by faxing a reservation form. Well before the deadline for the room reservations we will set up a system through which participants interested in finding room-mates can pair up. In the coming months we will also provide a list of nearby hotels with lower room rates. More information on all these issues will appear on the conference web site and will be circulated in our next circular some time in the middle of January.

CONFERENCE REGISTRATION

The deadline for early registration is March 1, 2010. The early-registration fee is equal to 250 euros (300 euros for late registration). This fee will cover the conference room, all coffee breaks, the registration reception on the evening of June 21, the conference dinner, and the proceedings book to be published in the AIP Conference Series. Information about how to register will appear on the conference web site and in our next circular.

IMPORTANT DEADLINES:

January 4, 2010	- submission of brief suggestions for presentations (to w-finney@northwestern.edu; e-mail subject: Presentation Suggestion by <your name here>)
February 15, 2010	- submission of presentation titles and abstracts
March 1, 2010	- early registration; announcement of tentative scientific program
March 15, 2010	- announcement of final scientific program
April 19, 2010	- room reservations at conference hotel & late registration

Please do not forget to check out the conference web site: `http://ciera.northwestern.edu/Ron-fest2010/`

Postdoc and research associate positions (2 to 5 years) in the Theoretical Astrophysics group of Ecole Normale Superieure de Lyon (ENS-Lyon).

Several postdoc and research associate positions (2 to 5 years) will be open in Theoretical Astrophysics group of Ecole Normale Superieure de Lyon (ENS-Lyon; head: G. Chabrier), in the domain of star and planet formation (see URL links below).

The positions can start as early as June 1st, 2010.
Contact for information: G. Chabrier, chabrier@ens-lyon.fr

http://members.aas.org/JobReg/JobDetailPage.cfm?JobID=26192
http://members.aas.org/JobReg/JobDetailPage.cfm?JobID=26193