$\mathcal{SCYON}$

The Star Clusters Young & Old Newsletter

edited by Holger Baumgardt, Ernst Paunzen and Thomas Puzia

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EDITORIAL

Dear subscribers,

This is the 57th issue of the SCYON newsletter. It contains 20 abstracts from refereed publications and an announcement for the Small Stellar Systems conference in Tuscany in June 2013. Todays issue is also the last issue with me as main editor. I would like to thank Ernst Paunzen for his great help in putting the issues together, sometimes at short notice. Thomas Puzia will take over editing the newsletter from me, starting with the next issue.

I would like to wish everybody a merry holiday season and a happy new year 2013 and thank all who sent us their contributions.

Holger Baumgardt

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@univie.ac.at.

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

Extended Star Formation in the Intermediate-age Large Magellanic Cloud Star Cluster NGC 2209

S.C. Keller, A.D. Mackey, and G.S. Da Costa
Australian National Univesity

We present observations of the 1 Gyr old star cluster NGC 2209 in the Large Magellanic Cloud made with the GMOS imager on the Gemini South Telescope. These observations show that the cluster exhibits a main-sequence turnoff that spans a broader range in luminosity than can be explained by a single-aged stellar population. This places NGC 2209 amongst a growing list of intermediate-age (1-3 Gyr) clusters that show evidence for extended or multiple epochs of star formation of between 50 and 460 Myr in extent. The extended main-sequence turnoff observed in NGC 2209 is a confirmation of the prediction in Keller et al. made on the basis of the cluster's large core radius. We propose that secondary star formation is a defining feature of the evolution of massive star clusters. Dissolution of lower mass clusters through evaporation results in only clusters that have experienced secondary star formation surviving for a Hubble time, thus providing a natural connection between the extended main-sequence turnoff phenomenon and the ubiquitous light-element abundance ranges seen in the ancient Galactic globular clusters.

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Evidence for Two Distinct Stellar Initial Mass Functions

Dennis Zaritsky, Janet E. Colucci, Peter M. Pessev, Rebecca A., Bernstein, and Rupali Chandar

University of Arizona, UCO/Lick Observatory, Gemini South Observatory, UCO/Lick Observatory, and University of Toledo

We present velocity dispersion measurements of 20 Local Group stellar clusters ($7 < \log(\text{age [yr]}) < 10.2$) from integrated light spectra and examine the evolution of the stellar mass-to-light ratio, Upsilon*. We find that the clusters deviate from the evolutionary tracks corresponding to simple stellar populations drawn from standard stellar initial mass functions (IMFs). The nature of this failure, in which Upsilon* is at first underestimated and then overestimated with age, invalidates potential simple solutions involving a rescaling of either the measured masses or modeled luminosities. A range of possible shortcomings in the strai ghtforward interpretation of the data, including subtleties arising from cluster dynamical evolution on the present-day stellar mass functions and from stellar binarity on the measured velocity dispersions, do not materially affect this conclusion given the current understanding of those effects. Independent of further conjectures regarding the origin of this problem, this result highlights a basic failing of our understanding of the integrated stellar populations of these systems. We propose the existence of two distinct IMFs, one primarily, but not exclusively, valid for older, metal-poor clusters and the other for primarily, but not exclusively, younger, metal-rich clusters. The young ($\log(\text{age [yr]}) < 9.5$) clusters are well described by a bottom-heavy IMF, such as a Salpeter IMF, while the older clusters are better described by a top-heavy IMF, such as a light-weighted Kroupa IMF, although neither of these specific forms is a unique solution. The sample is small, with the findings currently depending on the results for four key clusters, but doubling the sample is within reach.

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2. Galactic Open Clusters

Searching for multiple stellar populations in the massive, old open cluster Berkeley 39

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The most massive star clusters include several generations of stars with a different chemical composition (mainly revealed by an Na-O anti-correlation) while low-mass star clusters appear to be chemically homogeneous. We are investigating the chemical composition of several clusters with masses of a few 10^4 $M_\odot$ to establish the lower mass limit for the multiple stellar population phenomenon. Using FLAMES@VLT spectra we determine abundances of Fe, O, Na, and several other elements (alpha, Fe-peak, and neutron-capture elements) in the old open cluster Berkeley 39. This is a massive open cluster: $M \sim 10^4$ $M_\odot$, approximately at the border between small globular clusters and large open clusters. Our sample size of about 30 stars is one of the largest studied for abundances in any open cluster to date, and will be useful to determine improved cluster parameters, such as age, distance, and reddening when coupled with precise, well-calibrated photometry. We find that Berkeley 39 is slightly metal-poor, $< [Fe/H] >= -0.20$, in agreement with previous studies of this cluster. More importantly, we do not detect any star-to-star variation in the abundances of Fe, O, and Na within quite stringent upper limits. The r.m.s. scatter is 0.04, 0.10, and 0.05 dex for Fe, O, and Na, respectively. This small spread can be entirely explained by the noise in the spectra and by uncertainties in the atmospheric parameters. We conclude that Berkeley 39 is a single-population cluster.

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Massive open star clusters using the VVV survey II. Discovery of six clusters with Wolf-Rayet stars

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([1]) U. de Concepcion ([2]) U. de Valparaiso ([3]) The Milky Way Millennium Nucleus ([4]) U. Federal do Rio Grande do Sul ([5]) Saint Mary's University ([6]) IALP ([7]) U. of Hertfordshire ([8]) AIP ([9]) LAM ([10]) PUC de Chile ([11]) Queen Mary University of London ([12]) Kavli Institute for Astronomy and Astrophysics ([13]) U. de Liège ([14]) ESO ([15]) Centro de Astrofisica da Universidade do Porto ([16]) U. Montpellier II ([17]) Vatican Observatory ([18]) Princeton University

Context: The ESO Public Survey "VISTA Variables in the Via Lactea" (VVV) provides deep multi-epoch infrared observations for an unprecedented 562 sq. degrees of the Galactic bulge, and adjacent regions of the disk. In this survey nearly 150 new open clusters and cluster candidates have been discovered. Aims: This is the second in a series of papers about young, massive open clusters observed using the VVV survey. We present the first study of six recently discovered clusters. These clusters contain at least one newly discovered Wolf-Rayet (WR) star. Methods: Following the methodology presented in the first paper of the series, wide-field, deep JHKs VVV observations, combined with new infrared spectroscopy, are employed to constrain fundamental parameters for a subset of clusters. Results: We affirm that the six studied stellar groups are real young (2-7 Myr) and massive (between 0.8 and $2.2 \cdot 10^3$ $M_\odot$) clusters. They are highly obscured (Av $\sim$ 5-24 mag) and compact (1-2 pc). In addition to WR stars, two of the six clusters also contain at least one red supergiant star. We claim the discovery of 8 new WR stars, and 3 stars showing WR-like emission lines which could be classified WR or OIf. Preliminary analysis provides initial masses of $\sim$30-50 $M_\odot$ for the WR stars. Finally,we discuss the spiral structure of the Galaxy using as tracers the six new clusters together with the previously studied VVV clusters.

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Catch me if you can: is there a runaway-mass black hole in the Orion Nebula Cluster?

Ladislav Subr, Pavel Kroupa, Holger Baumgardt
(1) Charles University Prague, (2) University of Bonn, (3) University of Queensland

We investigate the dynamical evolution of the Orion Nebula Cluster (ONC) by means of direct N-body integrations. A large fraction of residual gas was probably expelled when the ONC formed, so we assume that the ONC was much more compact when it formed compared to its current size, in agreement with the embedded cluster radius-mass relation from Marks & Kroupa (2012). Hence, we assume that few-body relaxation played an important role during the initial phase of evolution of the ONC. In particular, three body interactions among OB stars likely led to their ejection from the cluster and, at the same time, to the formation of a massive object via runaway physical stellar collisions. The resulting depletion of the high mass end of the stellar mass function in the cluster is one of the important points where our models fit the observational data. We speculate that the runaway-mass star may have collapsed directly into a massive black hole ($M_{BH} > 100$ M$_\odot$). Such a dark object could explain the large velocity dispersion of the four Trapezium stars observed in the ONC core. We further show that the putative massive black hole is likely to be a member of a binary system with appr. 70 per cent probability. In such a case, it could be detected either due to short periods of enhanced accretion of stellar winds from the secondary star during pericentre passages, or through a measurement of the motion of the secondary whose velocity would exceed 10 km/s along the whole orbit.

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3. Galactic Globular Clusters

Identifying Contaminated K-band Globular Cluster RR Lyrae Photometry

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Acquiring near-infrared K-band (2.2 μm) photometry for RR Lyrae variables in globular clusters and nearby galaxies is advantageous since the resulting distances are less impacted by reddening and metallicity. However, K-band photometry for RR Lyrae variables in M5, Reticulum, M92, omega Cen, and M15 display clustercentric trends. HST ACS data imply that multiple stars in close proximity to RR Lyrae variables located near the cluster core, where the stellar density increases markedly, are generally unresolved in ground-based images. RR Lyrae variables near the cluster core appear to suffer from photometric contamination, thereby yielding underestimated cluster distances and biased ages. The impact is particularly pernicious since the contamination propagates a systematic uncertainty into the distance scale, and hinders the quest for precision cosmology. The clustercentric trends are probably unassociated with variations in chemical composition since an empirical K-band period-magnitude relation inferred from Araucaria/VLT data for RR Lyrae variables in the Sculptor dSph exhibits a negligible metallicity dependence: (0.059 ± 0.095)[Fe/H], a finding that supports prior observational results. A future multi-epoch high-resolution near-infrared survey, analogous to the optical HST ACS Galactic Globular Cluster Survey, may be employed to establish K-band photometry for the contaminating stars discussed here.

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On the impossible NGC 4372 V1 and V2: an extended AGB to the [Fe/H] = -2.2 cluster

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The asymptotic giant branch (AGB) of the globular cluster NGC 4372 appears to extend to unexpectedly high luminosities. We show, on the basis of proper motions and spatial distribution, that the extended AGB is indeed a likely part of the cluster. We also present the first spectra of the very cool (2600 K), very luminous (8000 Lsun), very dusty, oxygen-rich, purported long-period variable stars V1 and V2 that define the AGB tip. In particular, on the basis of their radial velocities, we conclude that V1 and V2 are probably members. We find that V1 and V2 are likely undergoing the superwind phase that terminates their nuclear-burning evolution. We hypothesise that the mass-loss processes that terminate the AGB are inhibited in NGC 4372 due to a lack of atmospheric pulsation and the high gas-to-dust ratio in the ejecta, leading to a delay in the associated enhanced mass loss and dust production. Previously predicted, but never observed, this explains the high mass of the white dwarf in Pease 1 in M15 without the need to invoke a stellar merger. If commonplace, this phenomenon has implications for the mass return from stars, the production of carbon stars and supernovae through the Universe's history, and the AGB contribution to light from unresolved metal-poor populations.

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Evidence for Two Distinct Stellar Initial Mass Functions

Dennis Zaritsky, Janet E. Colucci, Peter M. Pessev, Rebecca A., Bernstein, and Rupali Chandar

University of Arizona, UCO/Lick Observatory, Gemini South Observatory, UCO/Lick Observatory, and University of Toledo

We present velocity dispersion measurements of 20 Local Group stellar clusters ($7 < \log(\text{age [yr]}) < 10.2$) from integrated light spectra and examine the evolution of the stellar mass-to-light ratio, Upsilon*. We find that the clusters deviate from the evolutionary tracks corresponding to simple stellar populations drawn from standard stellar initial mass functions (IMFs). The nature of this failure, in which Upsilon* is at first underestimated and then overestimated with age, invalidates potential simple solutions involving a rescaling of either the measured masses or modeled luminosities. A range of possible shortcomings in the strai ghtforward interpretation of the data, including subtleties arising from cluster dynamical evolution on the present-day stellar mass functions and from stellar binarity on the measured velocity dispersions, do not materially affect this conclusion given the current understanding of those effects. Independent of further conjectures regarding the origin of this problem, this result highlights a basic failing of our understanding of the integrated stellar populations of these systems. We propose the existence of two distinct IMFs, one primarily, but not exclusively, valid for older, metal-poor clusters and the other for primarily, but not exclusively, younger, metal-rich clusters. The young ($\log(\text{age [yr]}) < 9.5$) clusters are well described by a bottom-heavy IMF, such as a Salpeter IMF, while the older clusters are better described by a top-heavy IMF, such as a light-weighted Kroupa IMF, although neither of these specific forms is a unique solution. The sample is small, with the findings currently depending on the results for four key clusters, but doubling the sample is within reach.

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4. Extragalactic Clusters

Extremely rapid star cluster disruption in high-shear circumnuclear starburst rings: the unusual case of NGC 7742

Richard de Grijs and Peter Anders

Kavli Institute for Astronomy and Astrophysics, Peking University, Yi He Yuan Lu 5, Hai Dian District, Beijing 100871, China

All known mass distributions of recently formed star cluster populations resemble a 'universal' power-law function. Here we assess the impact of the extremely disruptive environment in NGC 7742's circumnuclear starburst ring on the early evolution of the galaxy's high-mass ($\sim 10^5$–$10^7 M_\odot$) star cluster population. Surprisingly, and contrary to expectations, at all ages – including the youngest, < 15 Myr – the cluster mass functions are robustly and verifiably represented by lognormal distributions that resemble those commonly found only for old, evolved globular cluster systems in the local Universe. This suggests that the high-shear conditions in the NGC 7742 starburst ring may significantly speed up dynamical star cluster destruction. This enhanced mass-dependent disruption rate at very young ages might be caused by a combination of the starburst ring's high density and the shear caused by the counterrotating gas disk in the galaxy's inner region.

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Three newly discovered globular clusters in NGC 6822

A. P. Huxor, A. M. N. Ferguson, J. Veljanoski, A. D. Mackey, & N. R. Tanvir
ARI Heidelberg (Huxor)

We present three newly discovered globular clusters (GCs) in the Local Group dwarf irregular NGC 6822. Two are luminous and compact, while the third one is a very low luminosity diffuse cluster. We report the integrated optical photometry of the clusters, drawing on archival Canada-France-Hawaii Telescope/MegaCam data. The spatial positions of the new GCs are consistent with the linear alignment of the already known clusters. The most luminous of the new GCs is also highly elliptical, which we speculate may be due to the low tidal field in its environment.

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A VLT/FLAMES study of the peculiar intermediate-age Large Magellanic Cloud star cluster NGC 1846 - I. Kinematics

A. D. Mackey, G. S. Da Costa, A. M. N. Ferguson, & D. Yong
Australian National Univesity (Mackey, Da Costa, Yong), University of Edinburgh (Ferguson)

In this paper we present high resolution VLT/FLAMES observations of red giant stars in the massive intermediate-age Large Magellanic Cloud star cluster NGC 1846, which, on the basis of its extended main-sequence turn-off (EMSTO), possesses an internal age spread of ∼300 Myr. We describe in detail our target selection and data reduction procedures, and construct a sample of 21 stars possessing radial velocities indicating their membership of NGC 1846 at high confidence. We consider high-resolution spectra of the planetary nebula Mo-17, and conclude that this object is also a member of the cluster. Our measured radial velocities allow us to conduct a detailed investigation of the internal kinematics of NGC 1846, the first time this has been done for an EMSTO system. The key result of this work is that the cluster exhibits a significant degree of systemic rotation, of a magnitude comparable to the mean velocity dispersion. Using an extensive suite of Monte Carlo models we demonstrate that, despite our relatively small sample size and the substantial fraction of unresolved binary stars in the cluster, the rotation signal we detect is very like ly to be genuine. Our observations are in qualitative agreement with the predict ions of simulations modeling the formation of multiple populations of stars in globular clusters, where a dynamically cold, rapidly rotating second generation is a common feature. NGC 1846 is less than one relaxation time old, so any dynamical signatures encoded during its formation ought to remain present.

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The Initial Mass Function of Field OB Stars in the Small Magellanic Cloud

Lamb, J. B. Oey, M. S. Graus, A. S. Adams, F. C. Segura-Cox, D. M.
University of Michigan

Some theories of star formation suggest massive stars may only form in clustered environments, which would create a deficit of massive stars in low density environments. Observationally, Massey (2002) finds such a deficit in samples of the field population in the Small and Large Magellanic Clouds, with an IMF slope of Gamma 4. These IMF measurements represent some of the largest known deviations from the standard Salpeter IMF slope of Gamma=1.35. Here, we carry out a comprehensive investigation of the mass function above 20 solar masses for the entire field population of the Small Magellanic Cloud, based on data from the Runaways and Isolated O Type Star Spectroscopic Survey of the SMC (RIOTS4). This is a spatially complete census of the entire field OB star population of the SMC obtained with the IMACS multi-object spectrograph and MIKE echelle spectrograph on the Magellan telescopes. Based on Monte-Carlo simulations of the evolved present-day mass function, we find the slope of the field IMF above 20 solar masses is Gamma=2.3+/-0.4. We extend our IMF measurement to lower masses using BV photometry from the OGLE II survey. We use a statistical approach to generate a probability distribution for the mass of each star from the OGLE photometry, and we again find Gamma=2.3+/-0.6 for stellar masses from 7-20 solar masses. The discovery and removal of ten runaways in our RIOTS4 sample steepens the field IMF slope to Gamma=2.8+/-0.5. We discuss the possible effects of binarity and star-formation history on our results, and conclude that the steep field massive star IMF is most likely a real effect.

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Young accreted globular clusters in the outer halo of M31

A.D. Mackey, A.P. Huxor, A.M.N. Ferguson, M.J. Irwin, J. Veljanoski, A.W. McConnachie, R.A. Ibata, G.F. Lewis, and N.R. Tanvir

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We report on observations of two newly discovered globular clusters in the outskirts of M31 made using the Gemini Multi-Object Spectrograph (GMOS) instrument on Gemini North. These objects, PAndAS-7 (PA-7) and PAndAS-8 (PA-8), lie at a galactocentric radius of ≈ 87 kpc and are projected, with separation ≈ 19 kpc, on to a field halo substructure known as the South-West Cloud. We measure radial velocities for the two clusters which confirm that they are almost certainly physically associated with this feature. Colour-magnitude diagrams reveal strikingly short, exclusively red horizontal branches in both PA-7 and PA-8; both also have photometric [Fe/H] $= -1.35 \pm 0.15$. At this metallicity, the morphology of the horizontal branch is maximally sensitive to age, and we use the distinctive configurations seen in PA-7 and PA-8 to demonstrate that both objects are very likely to be at least 2 Gyr younger than the oldest Milky Way globular clusters. Our observations provide strong evidence for young globular clusters being accreted into the remote outer regions of M31 in a manner entirely consistent with the established picture for the Milky Way, and add credence to the idea that similar processes play a central role in determining the composition of globular cluster systems in large spiral galaxies in general.

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Hunting for Young Dispersing Star Clusters in IC 2574

Anne Pellerin, Martin M. Meyer, Daniela Calzetti, and Jason Harris.
Texas A&M University & Mount Allison University, University of Western Australia, University of Massachusetts, Illumina, Inc.

Dissolving stellar groups are very difficult to detect using traditional surface photometry techniques. We have developed a method to find and characterize non-compact stellar systems in galaxies where the young stellar population can be spatially resolved. By carrying out photometry on individual stars, we are able to separate the luminous blue stellar population from the star field background. The locations of these stars are used to identify groups by applying the HOP algorithm, which are then characterized using color-magnitude and stellar density radial profiles to estimate age, size, density, and shape. We test the method on Hubble Space Telescope Advanced Camera for Surveys archival images of IC 2574 and find 75 dispersed stellar groups. Of these, 20 highly dispersed groups are good candidates for dissolving systems. We find few compact systems with evidence of dissolution, potentially indicating that star formation in this galaxy occurs mostly in unbound clusters or groups. These systems indicate that the dispersion rate of groups and clusters in IC 2574 is at most 0.45 pc/Myr. The location of the groups found with HOP correlate well with H I contour map features. However, they do not coincide with H I holes, suggesting that those holes were not created by star-forming regions.

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Stacking Star Clusters in M51: Searching for Faint X-Ray Binaries

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The population of low-luminosity ($< 10^{35}$ erg s^{-1}) X-Ray Binaries (XRBs) has been investigated in our Galaxy and M31 but not further. To address this problem, we have used data from the *Chandra X-Ray Observatory* and the *Hubble Space Telescope* to investigate the faint population of XRBs in the grand-design spiral galaxy M51. A matching analysis found 25 star clusters coincident with 20 X-ray point sources within $1.5''$ (60 pc). From X-ray and optical color-color plots we determine that this population is dominated by high-mass XRBs. A stacking analysis of the X-ray data at the positions of optically-identified star clusters was completed to probe low-luminosity X-ray sources. No cluster type had a significant detection in any X-ray energy band. An average globular cluster had the largest upper limit, 9.23×10^{34} erg s^{-1}, in the full-band ($0.3 - 8$ keV) while on average the complete sample of clusters had the lowest upper limit, 6.46×10^{33} erg s^{-1} in the hard-band ($2 - 8$ keV). We determined average luminosities of the young and old star cluster populations and compared the results to those from the Milky Way. We conclude that deeper X-ray data is required to identify faint sources with a stacking analysis.

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Contact nvulic@uwo.ca
URL http://arxiv.org/abs/1212.0859

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5. Dynamical evolution - Simulations

Characterizing a cluster's dynamic state using a single epoch of radial velocities

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Context: Radial velocity measurements can be used to constrain the dynamical state of a stellar cluster. However, for clusters with velocity dispersions smaller than a few km/s the observed radial velocity distribution tends to be dominated by the orbital motions of binaries rather than the stellar motions through the potential well of the cluster. Aims. Our goal is to characterize the intrinsic velocity distribution of a cluster from a single epoch of radial velocity data even for a cluster with a velocity dispersion of a fraction of a km/s . Method: We investigate a maximum likelihood procedure, which was pioneered separately by Odenkirchen et al. (2002) and Kleyna et al. (2002). Assuming a period, mass ratio, and eccentricity distribution for the binaries in the observed cluster this procedure fits a dynamical model describing the velocity distribution for the single stars and center of masses of the binaries, simultaneously with the radial velocities caused by binary orbital motions, using all the information available in the observed velocity distribution. We test the capability of this procedure to reproduce the velocity dispersion of an observed cluster, using radial velocity data of an open cluster and Monte Carlo simulations. Results: We find that the fits to the intrinsic velocity distribution depend only weakly on the binary properties assumed, so the uncertainty in the fitted parameters tends to be dominated by statistical uncertainties. Based on a large suite of Monte Carlo simulations we provide an estimate of how these statistical uncertainties vary with the velocity dispersion, binary fraction, and the number of observed stars, which can be used to estimate the sample size needed to reach a specific accuracy. Finally we test the method on the well-studied open cluster NGC 188, showing that it can successfully reproduce a velocity dispersion of only 0.5 km/s using a single epoch of the multi-epoch radial velocity data. Conclusions: If the binary period, mass ratio, and eccentricity distribution of the observed stars are roughly known, this procedure can be used to correct for the effect of binary orbital motions on an observed velocity distribution. This allows for the study of the dynamical state of a stellar cluster with a small velocity dispersion from a single epoch of radial velocity data.

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Gas depletion in primordial globular clusters due to accretion onto stellar-mass black holes

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We consider the effect of compact stellar remnants on the interstellar medium of a massive star cluster following the initial burst of star formation. We argue that accretion onto stellar-mass black holes is an effective mechanism for rapid gas depletion in clusters of all masses, as long as they contain progenitor stars more massive than $> 50 M_{Sun}$. This scenario appears especially attractive for the progenitor systems of present-day massive globular clusters which likely had masses above M $> 10^7 M_{Sun}$. In such clusters, alternative mechanisms such as supernovae and stellar winds cannot provide a plausible explanation for the sudden removal of the primordial gas reservoir that is required to explain their complex chemical enrichment history.

In order to consider different regimes in the rate of gas accretion onto stellar mass black holes, we consider both the Bondi-Hoyle approximation as well as Eddington-limited accretion. For either model, our results show that the cluster gas can be significantly depleted within only a few tens of Myrs. In addition, this process will affect the distribution of black hole masses and, by extension, may accelerate the dynamical decoupling of the black hole population and, ultimately, their dynamical ejection. Moreover, the timescales for gas depletion are sufficiently short that the accreting black holes could significantly affect the chemistry of subsequent star formation episodes.

The gas depletion times and final mass in black holes are not only sensitive to the assumed model for the accretion rate, but also to the initial mass of the most massive black hole which, in turn, is determined by the upper mass cut-off of the stellar initial mass function. Given that the mass function of "dark" remnants is a crucial parameter for their dynamical ejection, our results imply that their accretion history can have an important bearing on the observed present-day cluster mass-to-light ratio. In particular, we show that the expected increase of the upper mass cut-off with decreasing metallicity could contribute to the observed anti-correlation between the mass-to-light ratio and the metallicity of globular clusters.

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Early evolution of the birth cluster of the solar system

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The solar system was most likely born in a star cluster containing at least 1000 stars. It is highly probable that this cluster environment influenced various properties of the solar system like its chemical composition, size and the orbital parameters of some of its constituting bodies. In the Milky Way, clusters with more than 2000 stars only form in two types - starburst clusters and leaky clusters - each following a unique temporal development in the mass-radius plane. The aim is here to determine the encounter probability in the range relevant to solar system formation for starburst or leaky cluster environments as a function of cluster age. N-body methods are used to investigate the cluster dynamics and the effect of gravitational interactions between cluster members on young solar-type stars surrounded by discs. Using the now available knowledge of the cluster density at a given cluster age it is demonstrated that in starburst clusters the central densities over the first 5 Myr are so high (initially $> 10^5$ Msun pc^{-3}) that hardly any discs with solar system building potential would survive this phase. This makes a starburst clusters an unlikely environment for the formation of our solar system. Instead it is highly probable that the solar system formed in a leaky cluster (often classified as OB association). It is demonstrated that an encounter determining the characteristic properties existing in our solar systems most likely happened very early on (< 2 Myr) in its formation history and that after 5 Myr the likelihood of a solar-type star experiencing such an encounter in a leaky cluster is negligible even if it was still part of the bound remnant. This explains why the solar system could develop and maintain its high circularity later in its development.

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Retention of Stellar-Mass Black Holes in Globular Clusters

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Globular clusters should be born with significant numbers of stellar-mass black holes (BHs). It has been thought for two decades that very few of these BHs could be retained through the cluster lifetime. With masses $\sim 10\,M_\odot$, BHs are ~ 20 times more massive than an average cluster star. They segregate into the cluster core, where they may eventually decouple from the remainder of the cluster. The small-N core then evaporates on a short timescale. This is the so-called Spitzer instability. Here we present the results of a full dynamical simulation of a globular cluster containing many stellar-mass BHs with a realistic mass spectrum. Our Monte Carlo simulation code includes detailed treatments of all relevant stellar evolution and dynamical processes. Our main finding is that old globular clusters could still contain many BHs at present. In our simulation, we find no evidence for the Spitzer instability. Instead, most of the BHs remain well-mixed with the rest of the cluster, with only the innermost few tens of BHs segregating significantly. Over the 12 Gyr evolution, fewer than half of the BHs are dynamically ejected through strong binary interactions in the cluster core. The presence of BHs leads to long-term heating of the cluster, ultimately producing a core radius on the high end of the distribution for Milky Way globular clusters (and those of other galaxies). A crude extrapolation from our model suggests that the BH–BH merger rate from globular clusters could be comparable to the rate in the field.

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6. Miscellaneous

A Search for OB Associations Near Southern Long-Period Cepheids. V. AQ Puppis and V620 Puppis

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A photometric UBV survey is presented for 610 stars in a region surrounding the Cepheid AQ Puppis and centered southwest of the variable, based upon photoelectric measures for 14 stars and calibrated iris photometry of photographic plates of the field for 596 stars. An analysis of reddening and distance for program stars indicates that the major dust complex in this direction is ∼1.8 kpc distant, producing differential extinction described by a ratio of total-to-selective extinction of R=Av/E(B-V)=3.10+-0.20. Zero-age main-sequence fitting for the main group of B-type stars along the line of sight yields a distance of 3.21 ± 0.19 kpc ($V_o - M_v = 12.53 \pm 0.13$ s.e.). The 29.97d Cepheid AQ Pup, of field reddening E(B-V)=0.47 ± 0.07 (E(B-V)(B0)=0.51 ± 0.07), appears to be associated with B-type stars lying within 5' of it as well as with a sparse group of stars, designated Turner 14, centered south of it at J2000.0 = 07:58:37, -29:25:00, with a mean reddening of E(B-V)=0.81 ± 0.01. AQ Pup has an inferred luminosity as a cluster member of $< M_v >= -5.40 \pm 0.25$ and an evolutionary age of $3 \cdot 10^7$ yr. Its observed rate of period increase of 300.1 ± 1.2 s/yr is an order of magnitude larger than what is observed for Cepheids of comparable period in the third crossing of the instability strip, and may be indicative of a high rate of mass loss or a putative fifth crossing. Another sparse cluster, designated Turner 13, surrounds the newly-recognized 2.59d Cepheid V620 Pup, of space reddening E(B-V)=0.64 ± 0.02 (E(B-V)(B0)=0.68 ± 0.02), distance 2.88 ± 0.11 kpc ($V_o - M_v = 12.30 \pm 0.08$ s.e.), evolutionary age 10^8 yr, and an inferred luminosity as a likely cluster member of $< M_v >= -2.74 \pm 0.11$. V620 Pup is tentatively identified as a first crosser, pending additional observations.

Accepted by : Astronomical Journal

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Small Stellar Systems in Tuscany: from Globular Clusters to Dwarf Galaxies and everything in between

10 - 14th June 2013, Prato, Italy

http://www.moca.monash.edu/conferences/compact

The aim of this conference is to bring together observers and theorists to discuss the latest observations and simulations of the "zoo of little things" including massive globular clusters (GCs), extended clusters (ECs), Ultra Compact Dwarfs (UCDs), dwarf galaxy transition objects (DGTOs), intermediate mass objects (IMOs), tidal dwarf galaxies (TDGs), dwarf elliptical (dE), dwarf spheroidal (dSph) and compact ellipticals (cE).

Scientific Rationale:

The distinction between dwarf galaxies and massive star clusters has become increasingly blurred. The parameter space of size and luminosity for small stellar systems is rapidly filling as one type of object overlaps with another. The stellar populations of massive star clusters are no longer "simple" with multiple populations of differing chemistry now commonly observed. Star clusters may appear to be dark matter free today and obey Newtonian dynamical laws, but there is less agreement over the presence and degree of dark matter in dwarf galaxies. The situation for intermediate-sized objects, such as Ultra Compact Dwarfs, is largely unknown. Sample sizes are often small limiting any statistical analysis.
The fundamental properties of these types of objects hold important clues to the origin and evolution of dwarf galaxies and massive star clusters. For example, are they ancient objects formed in a cosmological setting ? Have they been recently modified via merging of smaller subunits or by the stripping of their outer layers? Or are they products of the later stages of galaxy building and clustering?
The aim of this conference is to bring together observers and theorists to discuss the latest observations and simulations of the "zoo of little things" including massive globular clusters (GCs), extended clusters (ECs), Ultra Compact Dwarfs (UCDs), dwarf galaxy transition objects (DGTOs), intermediate mass objects (IMOs), tidal dwarf galaxies (TDGs), dwarf elliptical (dE), dwarf spheroidals (dSph), and compact ellipticals (cE).

Location:

The conference will be located in beautiful Tuscany. It will be held at the Monash Teaching Centre inPrato. The historic town ofPratolies a short distance north of Florence. The facilities enable a conference of 100 people to attend. We are planning to organise an excursion one afternoon to the Tuscan countryside.

Format:

The conference will consist of 4.5 days of Talks (and Posters). Regular Contributed talks and Invited talks will be chosen on the basis of the submitted abstracts. Ample question time will be allocated after each talk. We also intend to allocate some time to short presentations on "hot topics", such as: "What is the origin of Ultra Compact Dwarfs?". Registration fees are yet to be finalised but we intend to offer a discount to all current PhD students. The fee will be inclusive of the half day excursion and the conference dinner.

Important Dates:

Now: register your interest on the conference website
19 Jan 2013: Talk and Poster abstracts due
30 Jan 2013: Selected Talks and Postersannounced
28 Feb 2013: Registration Fee due (details to beannounced)
10-14 June 2013: Conference

SOC:

Duncan Forbes (co-chair),Samantha Penny (co-chair),Jay Gallagher,Jean Brodie Pavel Kroupa, Chris Conselice,Giampaolo Piotto,Thorsten Lisker