SCYON

The Star Clusters Young & Old Newsletter

edited by Holger Baumgardt and Ernst Paunzen

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`http://www.univie.ac.at/scyon`

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EDITORIAL

This is the 53rd issue of the SCYON newsletter. Todays issue contains 14 abstracts from refereed journals and conference proceedings and summaries of the PhD theses of Aldo Valcarce (Santiago) on helium enrichment in globular clusters and Andreas Küpper (Bonn) on the dynamical evolution of massive star clusters. Todays issue also includes an announcement for Special Session 1 at the upcoming IAU General assembly in Beijing next year. We finally have a job offer for two fixed-term lecturer positions at the University of Queensland (Australia).

We wish everybody a merry holiday season and a happy new year 2012 and thank all who sent us their contributions.

Holger Baumgardt and Ernst Paunzen

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SCYON POLICY

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

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

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

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

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

A “Call for abstracts” is sent out approximately one week before the next issue of the newsletter is finalised. This call contains the deadline for abstract submissions for that coming issue and the LaTeX abstract template.
Depending on circumstances, the editors might actively solicit contributions, usually those spotted on a preprint server, but they do not publish abstracts without the author’s consent.

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

The editors

SCYON Mirrors

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

1. Star Forming Regions

The massive star binary fraction in young open clusters - III. IC 2944 and the Cen OB2 association

H. Sana[1] G. James[2] E. Gosset[3]

[1]. Sterrenkundig Instituut Anton Pannekoek, Universiteit van Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands

[2]. European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching bei Munchen, Germany

[3]. Astrophysical Institute, Liege University, Bat. B5c, Allee du 6 Aout 17, B-4000 Liege, Belgium

Using an extended set of multi-epoch high-resolution high signal-to-noise ratio optical spectra, we readdress the multiplicity properties of the O-type stars in IC 2944 and in the Cen OB2 association. We present new evidence of binarity for five objects and we confirm the multiple nature of another two. We derive the first orbital solutions for HD 100099, HD 101436 and HD 101190 and we provide additional support for HD 101205 being a quadruple system. The minimal spectroscopic binary fraction in our sample is $f_{min} = 0.57$. Using numerical simulations, we show that the detection rate of our observational campaign is close to 90 per cent, leaving thus little room for undetected spectroscopic binary systems. The statistical properties of the O-star population in IC 2944 are similar, within the uncertainties, to the results obtained in the earlier papers in this series despite the fact that sample size effects limit the significance of the comparison. Using newly derived spectroscopic parallaxes, we reassess the distance to IC 2944 and obtained 2.3+/-0.3 kpc, in agreement with previous studies. We also confirm that, as far as the O stars are concerned, the IC 2944 cluster is most likely a single entity.

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G. Rauw[1]
[1] Institut d'Astrophysique & Geophysique, Liege University, Belgium

Cyg OB2 is one of the most massive associations of O-type stars in our Galaxy. Despite the large interstellar reddening towards Cyg OB2, many studies, spanning a wide range of wavelengths, have been conducted to more clearly understand this association. X-ray observations provide a powerful tool to overcome the effect of interstellar absorption and study the most energetic processes associated with the stars in Cyg OB2. We analyse XMM-Newton data to investigate the X-ray and UV properties of massive O-type stars as well as low-mass pre-main sequence stars in Cyg OB2. We obtained six XMM-Newton observations of the core of Cyg OB2. In our analysis, we pay particular attention to the variability of the X-ray bright OB stars, especially the luminous blue variable candidate Cyg OB2 #12. We find that X-ray variability is quite common among the stars in Cyg OB2. Whilst short-term variations are restricted mostly to low-mass pre-main sequence stars, one third of the OB stars display long-term variations. The X-ray flux of Cyg OB2 #12 varies by 37%, over timescales from days to years, whilst its mean $\log L_X/L_{bol}$ amounts to -6.10. These properties suggest that Cyg OB2 #12 is either an interacting-wind system or displays a magnetically confined wind. Two other X-ray bright O-type stars (MT91 516 and CPR2002 A11) display variations that suggest they are interacting wind binary systems.

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2. Galactic Open Clusters

Star Formation in the Outer Galaxy: Coronal Properties of NGC 1893

M. Caramazza[1], G. Micela[1], L. Prisinzano[1], S. Sciortino[1], F. Damiani[1], F. Favata[2], J. R. Stauffer[3], A. Vallenari[4] and S. J. Wolk[5]
[1]INAF Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy
[2]European Space Agency, 8-10 rue Mario Nikis, 75015 Paris, France
[3]Spitzer Science Center, Caltech 314-6, Pasadena, CA 91125, USA
[4]INAF, Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, 35122 Padova, Italy
[5]Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA

The outer Galaxy, where the environmental conditions are different from the solar neighbourhood is a laboratory in which it is possible to investigate the dependence of star formation process on the environmental parameters. We investigate the X-ray properties of NGC 1893, a young cluster ($\sim 1-2$ Myr) in the outer part of the Galaxy (galactic radius $\geq$ 11 kpc) where we expect differences in the disk evolution and in the mass distr ibution of the stars, to explore the X-ray emission of its members and compare it with that of young stars in st ar forming regions near to the Sun. We analyze 5 deep *Chandra* ACIS-I observations with a total exposure time of 450 ks. Source events of the 1021 X-ray sources have been extracted with the IDL-based routine ACIS-Extract. Using spectral fitting and quantile analysis of X-ray spectr a, we derive X-ray luminosities and compare the respective properties of Class II and Class III members. We also evaluate the variability of sources using the Kolmogorov-Smirnov test and we identify flares in the lightcurves. The X-ray luminosity of NGC 1893 X-ray members is in the range $10^{29.5} - 10^{31.5}$ erg s^{-1}. Diskless stars are brighter in X-rays than disk-bearing stars, given the same bolometric luminosity. We found that 34% of the 1021 lightcurves appear variable and that they show 0.16 flare per source, on average. Comparing our results with those relative to the Orion Nebula Cluster, we find that, accounting for observational biases, the X-ray properties of NGC 1893 and the Orion ones are very similar. The X-ray properties in NGC 1893 are not affected by the environment and the stellar population in the outer Galaxy may have the same coronal properties of nearby star forming regions. The X-ray luminosity properties and the X-ray luminosity function appear to be universal and can therefore be used for distance estimations and for determining stellar properties as already suggested by Feigelson and collaborators.

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New Evidence Supporting Membership for TW Nor in Lynga 6 and the Centaurus Spiral Arm

D. Majaess[1] D. Turner[1] C. Moni Bidin[2] F. Mauro[2] D. Geisler[2] W. Gieren[2] D. Minniti[3,4,5] A-N. Chene[2,7] P. Lucas[6] J. Borissova[7] R. Kurtev[7] I. Dekany[3] R. Saito[3]

[1]Saint Mary's University, Halifax, Nova Scotia, Canada [2]Universidad de Concepcion, Concepcion, Chile [3]Pontificia Universidad Catolica de Chile, Santiago, Chile [4]Vatican Observatory, Vatican City, Italy [5]Princeton University, Princeton, New Jersey, USA [6]University of Hertfordshire, Hatfield, United Kingdom [7]Universidad de Valparaiso, Valparaiso, Chile

The putative association between the 10.8 d classical Cepheid TW Nor and the open cluster Lynga 6 has generated considerable debate in the literature. New JHKs photometry in tandem with existing radial velocities for Lynga 6 stars imply cluster membership for TW Nor, and establish the variable as a high-weight calibrator for classical Cepheid relations. Fundamental mean parameters determined for Lynga 6 are: $d = 1.91 \pm 0.10$ kpc, $E(J-H) = 0.38 \pm 0.02$, and $log(t) = 7.9 \pm 0.1$. The Benedict et al.(2007)/Turner (2010) Galactic VIc Wesenheit function was revised using TW Nor's new parameters: $W_{VI,0} = (-3.37 \pm 0.08) log(P_0) - 2.48 \pm 0.08$. TW Nor/Lynga 6 lie beyond the Sagittarius-Carina spiral arm and occupy the Centaurus arm, along with innumerable young Cepheids and clusters (e.g., VW Cen & VVV CL070).

To appear in : ApJ Letters

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Formation and dissolution of leaky clusters

S. Pfalzner
Max-Planck-Institut für Radioastronomie

Massive Galactic clusters (> 1000 $M_\odot$) exhibit a clear correlation between cluster density, size and age and can be sorted in two categories, i.e. starburst and leaky clusters. The reason for the existance of two types of massive clusters is an open question. However, the answer is probably connected to a different formation histories of the two types. In this study we concentrate onleaky clusters only and investigate possible formation scenarios and gas expulsion phase. This is done by using existing observational data and numerical results of embedded cluster properties. Assuming that a clear correlation between cluster density, size and age exists, it is shown that the density-radius development over time for embedded clusters can be approximated by $\rho \approx 100 * r^{-1.3}$ $M_\odot$ pc^{-3}. The consequences for the star formation process in leaky clusters are discussed and found to favour an inside-out star formation scenario with an initially low but later accelerated star formation rate. It is shown how the leaky clusters form in a unique sequential manner and that rapid gas expulsion is responsible for the 80-90% mass loss over the next 20 Myr.

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New Results for the Open Cluster Bica 6 and its Associated Planetary Nebula Abell 8

D. G. Turner[1,5] **J. M. Rosvick**[2] **D. D. Balam**[3] **A. A. Henden**[4] **D. J. Majaess**[1,5] **D. J. Lane** [1,5]

[1] Saint Mary's University, Halifax, NS, Canada [2] Thompson Rivers University, Kamloops, BC, Canada [3] Dominion Astrophysical Observatory, Victoria, BC, Canada [4] AAVSO, Cambridge, MA, USA [5] Abbey Ridge Observatory, Stillwater Lake, NS, Canada

The likely membership of the planetary nebula Abell 8 (PN G167.0–00.9) in the open cluster Bica 6 is confirmed by CCD spectra, UBV(RI)c photometry, and radial velocities for luminous cluster stars. The reddening, estimated distance, and radial velocity of the planetary nebula agree with parameters derived for Bica 6 of E(B-V)=0.42, $d = 1.60 \pm 0.11$ kpc, and $V_r = 57 \pm 1$ km/s, with a cluster age of 1 Gyr, a diagnostic blue hook, and a few blue stragglers, including a peculiar B1 Vnn star (HDE 277593) that may be a post-AGB star. The results identify Bica 6 as a potential calibrator of the planetary nebula distance scale. The central star of the planetary nebula has a reddening of E(B-V)=0.49 ± 0.02, with a possible circumnebular excess, and an estimated luminosity of $M_V = +7.44 \pm 0.16$. It is also an optical double in 2MASS images, with a likely progenitor according to evolutionary considerations being a late B-type dwarf of ~ 2.3 $M_\odot$.

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3. Galactic Globular Clusters

Effects of Helium Enrichment in Globular Cluster Populations

Aldo A. R. Valcarce[1], Márcio Catelan[1], and Allen V. Sweigart[2]
[1]Pontificia Universidad Católica de Chile, Departamento de Astronomía y Astrofísica, Av. Vicuña Mackena 4860, 782-0436 Macul, Santiago, Chile
[2]NASA Goddard Space Flight Center, Exploration of the Universe Division, Code 667, Greenbelt, MD 20771, USA

Recently, the understanding of globular clusters (GCs) has drastically changed owing to the improvement in spectroscopic and photometric observations, which have shown that not all GCs could be considered simple stellar populations. Whilst spectroscopic studies have shown variations of some light elements in different degrees in all observed GCs (e.g., O-Na anticorrelation, Carretta et al. 2009), photometric studies have shown splits in some phases of color-magnitude diagrams (CMDs), where the triple main sequence (MS) detected in NGC 2808 has been attributed to differences in the helium abundance (ΔY, Piotto et al. 2007), which cannot be measured with enough precision in GCs. In this contribution, we show the other effects that must be observed in CMDs of GCs if ΔY is real.

To appear in the proceedings of the XIII Latin American Regional IAU Meeting, Morelia, Michoacán, México, 8 – 12 November, 2010, RevMexAA, ed. W. J.Henney, & S. Torres-Peimbert
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A Dynamical N-body Model for the Central Region of ω Centauri

B. Jalali[1] H. Baumgardt[2] M. Kissler-Patig[2] K. Gebhardt[3] E. Noyola[4,5] N. Lützgendorf [1] P. T. de Zeeuw[1]

[1] ESO; [2] University of Queensland; [3] University of Texas, Austin; [4] LMU, Munich; [5] UNAM

Supermassive black holes (SMBHs) are fundamental keys to understand the formation and evolution of their host galaxies. However, the formation and growth of SMBHs are not yet well understood. One of the proposed formation scenarios is the growth of SMBHs from seed intermediate-mass black holes (IMBHs, 10^2 to 10^5 $M_\odot$) formed in star clusters. In this context, and also with respect to the low mass end of the M-sigma relation for galaxies, globular clusters are in a mass range that make them ideal systems to look for IMBHs. Among Galactic star clusters, the massive cluster ω Centauri is a special target due to its central high velocity dispersion and also its multiple stellar populations. We study the central structure and dynamics of the star cluster ω Centauri to examine whether an IMBH is necessary to explain the observed velocity dispersion and surface brightness profiles. We perform direct N-body simulations to follow the dynamical evolution of ω Centauri. The simulations are compared to the most recent data-sets in order to explain the present-day conditions of the cluster and to constrain the initial conditions leading to the observed profiles. We find that starting from isotropic spherical multi-mass King models and within our canonical assumptions, a model with a central IMBH mass of 2% of the cluster stellar mass, i.e. a $5 \cdot 10^4$ $M_\odot$ IMBH, provides a satisfactory fit to both the observed shallow cusp in surface brightness and the continuous rise towards the center of the radial velocity dispersion profile. In our isotropic spherical models, the predicted proper motion dispersion for the best-fit model is the same as the radial velocity dispersion one.

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4. Extragalactic Clusters

The merger history, AGN and dwarf galaxies of Hickson Compact Group 59

I. S. Konstantopoulos[1], S. C. Gallagher[2], K. Fedotov[2,3], P. R. Durrell[4], P. Tzanavaris[5,6,7], A. R. Hill[2], A. I. Zabludoff[8], M. L. Maier[9], D. M. Elmegreen[10], J. C. Charlton[1], K. E. Johnson[11,12], W. N. Brandt[1], L. M. Walker[11], M. Eracleous[1], A. Maybhate[13], C. Gronwall[1], J. English[14], A. E. Hornschemeier[5], J. S. Mulchaey[15]

[1] Department of Astronomy; Astrophysics, The Pennsylvania State University, University Park, PA 16802; [2] Department of Physics & Astronomy, The University of Western Ontario, London, ON, N6A 3K7, Canada; [3] Herzberg Institute of Astrophysics, Victoria, BC V9E 2E7, Canada ; [4] Department of Physics & Astronomy, Youngstown State University, Youngstown, OH 44555; [5] Laboratory for X-ray Astrophysics, NASA Goddard Space Flight Center, Greenbelt, MD 20771; [6] Department of Physics; Astronomy, The Johns Hopkins University, Baltimore, MD 21218; [7] NASA Post-doctoral Program Fellow; [8] Steward Observatory, University of Arizona, Tucson, AZ 85721; [9] Gemini Observatory, Casilla 603, Colina el Pino S/N, La Serena, Chile; [10] Department of Physics & Astronomy, Vassar College, Poughkeepsie, NY 12604; [11] University of Virginia, Charlottesville, VA; [12] National Radio Astronomy Observatory, Charlottesville, VA; [13] Space Telescope Science Institute, Baltimore, MD; [14] University of Manitoba, Winnipeg, MN, Canada; [15] Carnegie Observatories, Pasadena, CA 91101

Compact group galaxies often appear unaffected by their unusually dense environment. Closer examination can, however, reveal t he subtle, cumulative effects of multiple galaxy interactions. Hickson Compact Group (HCG) 59 is an excellent example of this situation. We present a photometric study of this group in the optical (*HST*), infrared (*Spitzer*) and X-ray (*Chandra*) regimes aim ed at characterizing the star formation and nuclear activity in its constituent galaxies and intra-group medium. We associate five dwarf galaxies with the group and update the velocity dispersion, leading to an increase in the dynamical mass of the gr oup of up to a factor of 10 (to 2.8×10^{13} $M_{\odot}$), and a subsequent revision of its evolutionary stage. Star formation is proceeding at a level consistent with the morphological types of the four main galaxies, of which two are star-forming and the other two quiescent. Unlike in some other compact groups, star-forming complexes across HCG 59 closely follow mass-radius scaling relations typical of nearby galaxies. In contrast, the ancient globular cluster populations in galaxies HCG 59A and B show intriguing irregularities, and two extragalactic H II regions are found just west of B. We age-date a faint stel lar stream in the intra-group medium at ~ 1 Gyr to examine recent interactions. We detect a likely low-luminosity AGN in HCG 59A by its $\sim 10^{40}$ erg s^{-1} X-ray emission; the active nucleus rather than star formation can account for the UV+IR S ED. We discuss the implications of our findings in the context of galaxy evolution in dense environments.

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Also available from the URL https://files.me.com/iraklisk/ysogey

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5. Dynamical evolution - Simulations

Dynamical population synthesis: constructing the stellar single and binary contents of galactic field populations

Marks, Michael([1,2,3]) Kroupa, Pavel([1])

([1]) Argelander-Institut für Astronomie, Auf dem Hügel 71, 53121 Bonn ([2]) Max Planck Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn ([3]) Member of the International Max Planck Research School (IMPRS) for Astronomy and Astrophysics at the universities of Bonn and Cologne

The galactic field's late-type stellar single and binary populations are calculated on the observationally well-constrained supposition that all stars form as binaries with invariant properties in discrete star formation events. A recently developed tool (Marks, Kroupa & Oh) is used to evolve the binary star distributions in star clusters for a few million years until an equilibrium situation is achieved which has a particular mixture of single and binary stars. On cluster dissolution the population enters the galactic field with these characteristics. The different contributions of single stars and binaries from individual star clusters, which are selected from a power-law-embedded star cluster mass function, are then added up. This gives rise to integrated galactic field binary distribution functions (IGBDFs), resembling a galactic field's stellar content (dynamical population synthesis). It is found that the binary proportion in the galactic field of a galaxy is larger the lower the minimum cluster mass, $M_{\rm ecl,min}$, the lower the star formation rate, SFR, the steeper the embedded star cluster mass function (described by index β) and the larger the typical size of forming star clusters in the considered galaxy. In particular, period, mass ratio and eccentricity IGBDFs for the Milky Way (MW) are modelled using $M_{\rm ecl,min} = 5M_{\odot}$, SFR= $3M_{\odot}\ yr^{-1}$ and $\beta = 2$ which are justified by observations. For $r_h \approx 0.1 - 0.3$ pc, the half-mass radius of an embedded cluster, the aforementioned theoretical IGBDFs agree with independently observed distributions, suggesting that the individual discrete star formation events in the MW generally formed compact star clusters. Of all late-type binaries, 50 per cent stem from $M_{\rm ecl} \leq 300\ M_{\odot}$ clusters, while 50 per cent of all single stars were born in $M_{\rm ecl} \geq 10^4 M_{\odot}$ clusters. Comparison of the G-dwarf and M-dwarf binary populations indicates that the stars are formed in mass-segregated clusters. In particular, it is pointed out that although in the present model all M-dwarfs are born in binary systems, in the MW's Galactic field the majority ends up being single stars. This work predicts that today's binary frequency in elliptical galaxies is lower than that in spiral and dwarf galaxies. The period and mass-ratio distributions in these galaxies are explicitly predicted.

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Tidal mass loss in star clusters and treatment of escapers in Fokker-Planck models

Takahashi, Koji[1]; Baumgardt, Holger[2]
[1] Saitama Institute of Technology, Japan [2] University of Queensland, Australia

This paper presents a new scheme to treat escaping stars in the orbit-averaged Fokker-Planck models of globular star clusters in a galactic tidal field. The existence of a large number of potential escapers, which have energies above the escape energy but are still within the tidal radius, is taken into account in the models. The models allow potential escapers to experience gravitational scatterings before they leave clusters and thus some of them may lose enough energy to be bound again. It is shown that the mass evolution of the Fokker-Planck models are in good agreement with that of N-body models including the full tidal-force field. The mass-loss time does not simply scale with the relaxation time due to the existence of potential escapers; it increases with the number of stars more slowly than the relaxation time, though it tends to be proportional to the relaxation time in the limit of a weak tidal field. The Fokker-Planck models include two parameters, the coefficient gamma in the Coulomb logarithm $\ln \gamma N$ and the coefficient ν_e controlling the efficiency of the mass loss. The values of these parameters are determined by comparing the Fokker-Planck models with the N-body models. It is found that the parameter set $(\gamma, \nu_e) = (0.11, 7)$ works well for both single-mass and multi-mass clusters, but that the parameter set $(\gamma, \nu_e) = (0.02, 40)$ is another possible choice for multi-mass clusters.

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More on the structure of tidal tails

Andreas H.W. Küpper[1], Richard R. Lane[2] and Douglas C. Heggie[3]
[1]Argelander Institut für Astronomie (AIfA), Auf dem Hügel 71, 53121 Bonn, Germany,
[2]Departamento de Astronomía, Universidad de Concepción, Casilla 160 C, Concepción, Chile,
[3]University of Edinburgh, School of Mathematics and Maxwell Institute for Mathematical Sciences, King's Buildings, Edinburgh EH9 3JZ

We investigate the epicyclic motion of stars escaping from star clusters. Using streaklines, we visualise the path of escaping stars and show how epicyclic motion leads to over- and underdensities in tidal tails of star clusters moving on circular and eccentric orbits about a galaxy. Additionally, we investigate the effect of the cluster mass on the tidal tails, by showing that their structure is better matched when the perturbing effect of the cluster mass is included. By adjusting streaklines to results of N-body computations we can accurately and quickly reproduce all observed substructure, especially the streaky features often found in simulations which may be interpreted in observations as multiple tidal tails. Hence, we can rule out tidal shocks as the origin of such substructures. Finally, from the adjusted streakline parameters we can verify that for the star clusters we studied escape mainly happens from the tidal radius of the cluster, given by $x_L = (GM/(\Omega^2 - \partial^2\Phi/\partial R^2))^{1/3}$. We find, however, that there is another limiting radius, the "edge" radius, which gives the smallest radius from which a star can escape during one cluster orbit about the galaxy. For eccentric cluster orbits the edge radius shrinks with increasing orbital eccentricity (for fixed apocentric distance) but is always significantly larger than the respective perigalactic tidal radius. In fact, the edge radii of the clusters we investigated, which are extended and tidally filling, agree well with their (fitted) King radii, which may indicate a fundamental connection between these two quantities.

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The Effect of a Tidal Field on the Depletion of Dark Matter from Globular Clusters

E. Ardi ([1]) and H. Baumgardt ([2])

([1]) Kyoto International University, Kyoto, Japan ([2]) University of Queensland, Brisbane, Australia

Numerical simulations are conducted to follow the evolution of models of globular clusters composed out of stars and dark matter. We found that the dark matter is depleted from the the center of globular clusters due to dynamical friction and mass segregation of stars. The globular clusters have expelled almost all amount of the dark matter from their cores in 1.5 friction times. An external tidal field depletes the dark matter from a globular cluster to less than 20 % of the initial value within 2 friction times, however more than 80 % of the initial dark matter still remains in the outer part of the clusters. Our results could imply the existence of significant amounts of dark matter in the outer parts of some clusters.

To appear in : Proceedings of the 11-th Asian-Pacific Regional IAU Meeting 2011, 26-29 July 2011, Chiang Mai, Thailand

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Cluster Disruption: From infant mortality to long term survival

Nate Bastian
Excellence Cluster "Universe", Technical University Munich

How stellar clusters disrupt, and over what timescales, is intimately linked with how they form. Here, we review the theory and observations of cluster disruption, both the suggested initial rapid dissolution phase (infant mortality) and the longer timescale processes that affect clusters after they emerge from their progenitor GMCs. Over the past decade, the standard paradigm that has developed is that all/most stars are formed in clusters and that the vast majority of these groups are disrupted over short timescales (< 10 Myr). This is thought to be due to the removal of the left over gas from the star-formation process, known as infant mortality. However, recent results have suggested that the fraction of stars that form in clusters has been overestimated, with the majority being formed in unbound groups (i.e. associations) which expand and disrupt without the need of invoking gas removal. Dynamical measurements of young massive clusters in the Galaxy suggest that clusters reach a stable equilibrium at very young (< 3 Myr) ages, suggesting that gas expulsion has little effect on the cluster. After the early dynamical phase, clusters appear to be long lived and stable objects. We use the recent WFC3 image of the cluster population in M83 to test empirical disruption laws and find that the lifetime of clusters strongly depends on their ambient environment. While the role of cluster mass is less well constrained (due to the added parameter of the form of the cluster mass function), we find evidence suggesting that higher mass clusters survive longer, and that the cluster mass function (at least in M83, outside the nuclear region) is truncated above $\sim 10^5$ $M_\odot$.

To appear in : Invited review for the proceedings of "Stellar Clusters and Associations - A RIA workshop on GAIA", 23-27 May 2011, Granada, Spain
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Study of the Helium Enrichment in Globular Clusters

Aldo A. R. Valcarce
Pontificia Universidad Católica de Chile, Departamento de Astronomía y Astrofísica,
Av. Vicuña Mackena 4860, 782-0436 Macul, Santiago, Chile

In the last few years, there has been increasing evidence that the hypothesis that globular clusters (GCs) are well-defined by a simple stellar population (SSP) is ruled out, for at least some of them. In fact, the multiple populations observed in color-magnitude diagrams (CMDs) of GCs (especially along the main sequences) suggest that there is a helium spread among stars in a given GC.

In this thesis, we study the effects that must be observed along the different evolutionary phases of the CMDs of GCs if a helium spread is present. This is carried out using isochrones and zero-age horizontal branch (ZAHB) loci computed with the Princeton-Goddard-PUC (PGPUC) stellar evolutionary code, for the chemical compositions observed in GCs and initial helium abundances between Y=0.230 and 0.370.

Isochrones and ZAHB loci were compared with Hubble Space Telescope Advanced Camera for Surveys data for two GCs: M3 (NGC 5272) and NGC 2808. In the case of M3, we determine that it is well defined by a SSP with an age of ∼13 Gyr with $Y \lesssim 0.245$, plus a possible small subpopulation (∼3.4%) with a higher helium abundance. For NGC 2808 an age of ∼11.5 Gyr was determined, while it was not possible to determine a precise Y value owing to the multiple populations previously detected in this GC. In spite of the unknown Y values, this GC presents color distributions and luminosity functions along the whole CMD suggesting that the helium spread is real. However, we found that the complete CMD of NGC 2808 is better represented by populations with [Fe/H]=-1.35 instead of the literature value ([Fe/H]=-1.14) for this GC, which can induce a slightly overestimation of the He abundance associated with the most He-enriched stellar components.

Finally, a new scenario for the formation and chemical evolution of GCs is outlined. In this scenario, the main parameter which discriminates among the various possible outcomes is the initial mass of the molecular cloud (the progenitor structure, PS hereinafter) from which the GC formed. More in detail: i) Massive PSs can retain the gas ejected by massive stars, including the ejecta of core-collapse SNe. ii) Intermediate-mass PSs can retain at least a fraction of the fast winds of massive stars, but none of the core-collapse SNe ejecta. iii) Low-mass PSs can only retain the slow winds of intermediate-mass stars. Members of the first group would include ω Centauri (NGC 5139) and M54 (NGC 6715), whereas NGC 2808 would be a member of the second group. GCs which only present a spread in light elements, such as O and Na, would be members of the third group, and would accordingly be expected to present only minor levels of He enhancement. We emphasize that in this scenario the rôle of the ejecta of massive stars is crucial to understand the chemical evolution of GCs.

Electronic mail: avalcarc@astro.puc.cl
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For preprints, contact avalcarc@astro.puc.cl

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Dynamical evolution of massive star clusters

Andreas H.W. Küpper[1]
[1]Argelander Institut für Astronomie (AIfA), Auf dem Hügel 71, 53121 Bonn, Germany

The majority of stars is born in star clusters of different sizes and masses. But star clusters are dynamically unstable objects; they dissolve due to a continuos exchange of energy between the constituent stars. In this thesis, the dissolution process of massive star clusters is studied by means of high-performance N-body computations. Such investigations have only recently become feasible due to the availability of sophisticated accelerator hardware and adapted codes like NBODY6.

First, the formation of tidal tails by star clusters which orbit about a galaxy is studied. It is found that stars, when they escape, move on epicyclic orbits away from the cluster. This motion produces a standing wave in the tidal tails when performed by a continuous stream of escapers, and can be detected as overdense and underdense regions in such stellar streams. This mechanism is investigated for a broad range of cluster types and orbits. Moreover, it is tested whether other mechanisms, e.g. tidal shocks, can produce overdensities in tidal tails as well. It is shown that epicyclic motion is the main reason for substructure in the tidal tails of all investigated star clusters. Hence, the substructures existent in observed tidal tails of Milky-Way globular clusters (e.g. Palomar 5) are likely to be epicyclic overdensities.

Furthermore, it is demonstrated that the dissolution process has a strong influence on the appearance of star clusters. Prior to escape, energetically unbound stars orbit for some time within the cluster and cause the cluster's velocity dispersion to deviate from its Newtonian expectation in the outer parts of the cluster. Moreover, for star clusters on eccentric orbits, the distance between stars in the tails and the cluster changes periodically due to differential acceleration. That is, between apogalacticon and perigalacticon this distance increases, whereas it decreases on the way back to apogalacticon. This orbital compression causes a periodically changing stellar density in the outer part of such a cluster. While star clusters usually show a slope of R^{-5} at large cluster radii within their projected radial surface density profile, this slope increases up to R^{-1} for clusters on eccentric orbits close to apogalacticon. Therefore, the stellar density in the outer parts of a cluster can be used to gain information on its orbital phase. In a case study of the globular cluster Palomar 13 this behaviour is illustrated.

Finally, the publicly available code McLUSTER is presented, which can be used to set-up star cluster models for N-body computations or for direct study. It originated from the work done throughout this thesis and is now officially part of the NBODY6 package by Dr. Sverre Aarseth from Cambridge, UK. The capabilities of this code are demonstrated by testing methods from the literature for detecting and quantifying mass segregation and substructure in star clusters. For this purpose, several models of the young massive cluster R136 in the Large Magellanic Cloud are generated and analysed.

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The McLUSTER *code is available from the URL* `www.astro.uni-bonn.de/~akuepper/`

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Origin and Complexity of Massive Star Clusters

IAU XXVIII General Assembly (Beijing, China)

Special Session 1 (August 20-24, 2012)

Scientific Rationale

In the last few years, high precision photometric and spectroscopic observations have provided strong evidence that the presence of multiple stellar generations is a widespread phenomenon among star clusters, subverting the long lasting paradigm that these objects are simple stellar populations, composed of stars with the same age and chemical composition. These findings have raised a number of fundamental questions concerning the origin and evolution of star clusters, the nature of the first generation of stars which must have provided the gas for the formation of subsequent stellar generations, the link between star clusters and other massive stellar systems (such as nuclear star clusters and dwarf galaxies), and the relationship between star cluster and field stellar populations. Addressing these questions requires the expertise of observers and theoreticians working on stellar evolution, nuclear astrophysics, hydrodynamics, stellar dynamics, high precision astrometric, photometric, and spectroscopic observations of Galactic and extragalactic globular clusters, nuclear star clusters and dwarf galaxies. This Special Session will allow these specialists to have a global view of the different topics related to the multiple stellar populations in star clusters, appreciate the network of constraints and implications of this research field, and discuss the future strategy for the comprehension of phenomena which remain still largely unexplained.

List of Topics

1. Multiple stellar populations in Galactic and extragalactic globular star clusters
2. Multiple population star cluster formation and dynamical evolution
3. Stellar evolution and the chemical evolution of star clusters
4. Relation between globular clusters, dwarf galaxies, nuclear star clusters
5. Relation between globular cluster stellar populations and Galactic halo, disk and bulge stars

Registration

Registration for Special Session 1 must be done through the IAU General Assembly website. The deadline for early online registration is September 1, 2011 until February 29, 2012. Regular online online registration is possible until August 10, 2012.

Abstract Submissions

Submission of abstracts (for posters and contributed talks) for Special Session 1 must be done through the IAU General Assembly website. Deadline for abstract submission is February 29, 2012.

For more information, check the following website:

`http://www.physics.drexel.edu/~sps1_2012/`

or contact the co-Chairs of the SOC, Giampaolo Piotto and Enrico Vesperini at

`sps1_2012 @ physics.drexel.edu`

Two Fixed Term Lecturer positions in Physics

Applications are invited for two lecturer positions in physics at the University of Queensland, Australia. The successful appointee will have a strong desire to engage in an active research program in one of the School's physics research strength areas (astrophysics, biophotonics and laser science, condensed matter physics, and quantum science). He/she will also undertake teaching of undergraduate and postgraduate courses in the Physics program.

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