# $\mathcal{SCYON}$

*The Star Clusters Young & Old Newsletter*

edited by Holger Baumgardt and Ernst Paunzen

SCYON can be found at URL:
`http://www.univie.ac.at/scyon/`

*SCYON Issue No. 50* *March 11, 2011*


## EDITORIAL

Dear Colleagues,

With the current issue SCYON celebrates its 50th publication. Todays edition also marks the 10th anniversary since the creation of SCYON. We would therefore like to send our special thanks to everybody who has send us a contribution during the last 10 years and help make SCYON a success story. The number of subscribers has steadily risen over the years and we currently have 570 subscribers in 31 countries. Also the number of abstracts which appear in each Newsletter has steadily risen but still many are missing. We therefore urge every subscriber to submit us their abstracts.

With todays edition Pavel Kroupa will step down as editor of SCYON. We would like to thank Pavel for his work with the newsletter and wish him all the best for the future.

Todays issue contains 18 abstracts from refereed publications and an announcement for a postdoc position at the Universidad Catolica in Santiago. We also have an announcement by Marco Castellani for a group devoted to star cluster research on CiteULike, which is a new webservice aimed at sharing academic papers. We encourage everybody to send their papers to CiteULike, which can easily be done once they are published on astro-ph.

As usual we would like to thank all who sent us their contributions.

Holger Baumgardt and Ernst Paunzen

## 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@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

---

# 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/)

---

# 1. Star Forming Regions

## From the molecular-cloud- to the embedded-cluster-mass function with a density threshold for star formation

**Geneviève Parmentier**[1]

[1]Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany

The mass function $dN \propto m^{-\beta_0} dm$ of molecular clouds and clumps is shallower than the mass function $dN \propto m^{-\beta_\star} dm$ of young star clusters, gas-embedded and gas-free alike, as their respective mass function indices are $\beta_0 \simeq 1.7$ and $\beta_\star \simeq 2$. We demonstrate that such a difference can arise from different mass-radius relations for the embedded-clusters and the molecular clouds (clumps) hosting them. In particular, the formation of star clusters with a constant mean *volume* density in the central regions of molecular clouds of constant mean *surface* density steepens the mass function from clouds to embedded-clusters. This model is observationally supported since the mean surface density of molecular clouds is approximately constant, while there is a growing body of evidence, in both Galactic and extragalactic environments, that efficient star-formation requires a hydrogen molecule number density threshold of $n_{th} \simeq 10^{4-5}\, cm^{-3}$.

Adopting power-law volume density profiles of index $p$ for spherically symmetric molecular clouds (clumps), we define two zones within each cloud (clump): a central cluster-forming region, actively forming stars by virtue of a local number density higher than $n_{th}$, and an outer envelope inert in terms of star formation. We map how much the slope of the cluster-forming region mass function differs from that of their host-clouds (clumps) as a function of their respective mass-radius relations and of the cloud (clump) density index. We find that for constant surface density clouds with density index $p \simeq 1.9$, a cloud mass function of index $\beta_0 = 1.7$ gives rise to a cluster-forming region mass function of index $\beta \simeq 2$. Our model equates with defining two distinct SFEs: a global mass-varying SFE averaged over the whole cloud (clump), and a local mass-independent SFE measured over the central cluster-forming region. While the global SFE relates the mass function of clouds to that of embedded-clusters, the local SFE rules cluster evolution after residual star-forming gas expulsion. That the cluster mass function slope does not change through early cluster evolution implies a mass-independent local SFE and, thus, the same mass function index for cluster-forming regions and embedded-clusters, that is, $\beta = \beta_\star$. Our model can therefore reproduce the observed cluster mass function index $\beta_\star \simeq 2$.

For the same model parameters, the radius distribution also steepens from clouds (clumps) to embedded-clusters, which contributes to explaining observed cluster radius distributions.

**To appear in: Monthly Notices of the Royal Astronomical Society**
*For preprints, contact* `gparm@astro.uni-bonn.de`
*Also available from the URL* `http://xxx.lanl.gov/abs/1101.0813`
*or by anonymous ftp at*

.....

# 2. Galactic Open Clusters

## GLIMPSE-CO1: the most massive intermediate-age stellar cluster in the Galaxy

**Davies, Ben ([1,2]); Bastian, Nate ([3]); Gieles, Mark ([1]); Seth, Anil C. ([4]); Mengel, Sabine ([5]); Konstantopoulos, Iraklis S. ([6])**

[1] - IoA, Cambridge [2] - Leeds [3] - University Observatory Munich [4] - Harvard [5] - ESO [6] - Penn State

The stellar cluster GLIMPSE-C01 is a dense stellar system located in the Galactic plane. Though often referred to in the literature as an old globular cluster traversing the Galactic disc, previous observations do not rule out that it is an intermediate-age (less than a few Gyr) disc-borne cluster. Here, we present high-resolution near-infrared spectroscopy of over 50 stars in the cluster. We find an average radial velocity is consistent with being part of the disc, and determine the cluster's dynamical mass to be $(8 \pm 3) \times 10^4$ Msun. Analysis of the cluster's M/L ratio, the location of the red clump and an extremely high stellar density, all suggest an age of 400-800 Myr for GLIMPSE-C01, much lower than that for a typical globular cluster. This evidence therefore leads us to conclude that GLIMPSE-C01 is a part of the disc population, and is the most massive Galactic intermediate-age cluster discovered to date.

**Accepted by : Monthly Notices of the Royal Astronomical Society**
*For preprints, contact* `bdavies@ast.cam.ac.uk`
*Also available from the URL* `http://adsabs.harvard.edu/abs/2011MNRAS.411.1386D`
*or by anonymous ftp at* `ftp://`

.....

# High resolution elemental abundance analysis of the Hyades Supercluster

**G.M. De Silva([1]), K.C. Freeman([2]), J. Bland-Hawthorn([3]), M. Asplund([4]), M. Williams([5]), J. Holmberg([6])**

[1]. AAO, Australia [2]. RSAA, ANU, Australia [3]. U. Sydney, Australia [4]. MPA, Germany [5]. AIP, Germany [6]. Niels Bohr Institute, Denmark

The existence of a kinematically defined moving group of stars centred at U = 40 V = -17 km/s referred to as the Hyades Supercluster, has been suggested as the debris of an originally large star forming event, with its core being the present day Hyades open cluster. Using high-resolution UVES spectra, we present elemental abundances for a range of alpha, Fe-peak and neutron-capture elements for 26 proposed supercluster stars. Our results show that the sample stars display a heterogeneous abundance distribution, with a clump around [Fe/H] = +0.15. We also calculate stellar radial velocities and U,V,W space velocities. Enforcing a strict chemical and kinematical membership criteria, we find 4 supercluster stars share the Hyades open cluster abundances and kinematics, while many of the remaining stars fit the disc field kinematics and abundance range. We discuss our findings in the context of the Hyades supercluster being a dispersed star-forming remnant, a stellar stream of purely dynamical origin or a result of several processes.

**Submitted to : Monthly Notices of the Royal Astronomical Society**
*For preprints, contact* `gdesilva@aao.gov.au`
*Also available from the URL* `http://`
*or by anonymous ftp at* `ftp://`

.....

# A massive association around the obscured open cluster RSGC3

**Ignacio Negueruela ([1]), Carlos González-Fernández ([1]), Amparo Marco ([1]) & J. Simon Clark ([2])**

([1]) Universidad de Alicante ([2]) Open University

Four clusters of red supergiants have been discovered in a region of the Milky Way close to base of the Scutum-Crux Arm and the tip of the Long Bar. Population synthesis models indicate that they must be very massive to harbour so many supergiants. If the clusters are physically connected, this Scutum Complex would be the largest and most massive star-forming region ever identified in the Milky Way.

The spatial extent of one of these clusters, RSGC3, has not been investigated. In this paper we explore the possibility that a population of red supergiants could be located in its vicinity.

We utilised 2MASS JHK$_S$ photometry to identify candidate obscured luminous red stars in the vicinity of RSGC3. We observed a sample of candidates with the TWIN spectrograph on the 3.5-m telescope at Calar Alto, obtaining intermediate-resolution spectroscopy in the 8000-9000 range. We re-evaluated a number of classification criteria proposed in the literature for this spectral range and found that we could use our spectra to derive spectral types and luminosity classes.

We measured the radial velocity of five members of RSGC3, finding velocities similar to the average for members of Stephenson 2. Among the candidates observed outside the cluster, our spectra revealed eight M-type supergiants at distances ¡18' from the centre of RSGC3, distributed in two clumps. The southern clump is most likely another cluster of red supergiants, with reddening and age identical to RSGC3. From 2MASS photometry, we identified four likely supergiant members of the cluster in addition to the five spectroscopically observed. The northern clump may be a small cluster with similar parameters. Photometric analysis of the area around RSGC3 suggests the presence of a large ($> 30$) population of red supergiants with similar colours.

Our data suggest that the massive cluster RSGC3 is surrounded by an extended association, which may be very massive ($> 10^5 M_\odot$). We also show that supergiants in the Scutum Complex may be characterised via a combination of 2MASS photometry and intermediate-to-high-resolution spectroscopy in the Z band.

**Accepted by : Astronomy & Astrophysics**

*For preprints, contact* ignacio.negueruela@ua.es

*Also available from the URL* http://esoads.eso.org/abs/2011arXiv1102.0028N

*or by anonymous ftp at* ftp://

.....

# New spectroscopic classifications of 35 chemically peculiar candidate stars

**E. Paunzen[1], M. Netopil[1,2], O.I. Pintado[3], and M. Rode-Paunzen[1]**

[1]Institut für Astronomie der Universität Wien, Türkenschanzstr. 17, A-1180 Wien, Austria, [2]Institute of Theoretical Physics and Astrophysics, Masaryk University, CZ-611 37 Brno, Czech Republic, [3]Instituto Superior de Correlación Geológica (INSUGEO), 4000 Tucumán, Argentina

The chemically peculiar (CP) stars of the upper main sequence are perfect tracers for several astrophysical processes. Their study especially in open clusters further helps to establish their evolutionary status. The latter is most important to understand the origin and evolution of the CP phenomenon, i.e. the connection between diffusion and a stellar magnetic field. There are two important topics, we cover with this paper. First of all, we investigate the reliability of the CCD $\Delta$a photometry for fainter objects in open clusters. The latter method is able to detect CP stars very efficiently, but still a spectroscopic verification is needed to verify the photometric candidates. On the other hand, already published spectral classifications on the basis of photographic plates and prism technology have to be tested with modern instruments. Classification resolution spectroscopy is presented for thirty five bona-fide CP candidates. Twenty six of them are located within the boundaries of fourteen open clusters, for which we also investigated their membership probabilities. Apart from five objects, they seem to be members of the respective clusters. The objects were classified in the framework of a refined Morgan-Keenan system with the extension of well established CP star spectra. We confirm the CP nature of all but one target. The results of $\Delta$a photometry and the spectral classifications are in excellent agreement. For the cluster members we find a continuous sequence of CP stars from 10 to 850 Myr, the whole range of investigated cluster ages.

**Published in the Astronomische Nachrichten, Vol. 332, Issue 1, p. 77 (2011)**

*For preprints, contact* ernst.paunzen@univie.ac.at

*Also available from the URL*

*or by anonymous ftp at*

. . . . . .

# The Usefulness of 2MASS JHKs Photometry for Open Cluster Studies

**David G. Turner**
Saint Mary's University, Halifax, Nova Scotia, Canada.

2MASS JHKs data are used to infer the reddening and distance of open clusters for which limited optical data are available. Intrinsic ZAMS color-color and color-magnitude relations are derived with reference to existing calibrations, standard stars, three uniformly-reddened clusters: Stock 16, NGC 2362, and NGC 2281, and unreddened Hyades dwarfs. The method of inferring interstellar reddening and distance for sparsely-populated open clusters is applied to Berkeley 44, Turner 1, and Collinder 419, for which existing results conflict with those inferred from JHKs data. The last two clusters are of special interest: Turner 1 because it hosts the Galaxy's longest-period classical Cepheid, and Collinder 419 because it lies in the Cygnus X complex.

**To appear in : RMAA**
*For preprints, contact* `turner@ap.smu.ca`
*Also available from the URL* `http://arxiv.org/abs/1102.0347`
*or by anonymous ftp at* `ftp://`

. . . . . .

# 3. Galactic Globular Clusters

## Mining SDSS in search of multiple populations in globular clusters

**C. Lardo, M. Bellazzini, E. Pancino, E. Carretta, A. Bragaglia, and E. Dalessandro**
Department of Astronomy, University of Bologna, via Ranzani 1, 40127 Bologna, Italy. INAF - Osservatorio Astronomico di Bologna, via Ranzani 1, 40127 Bologna, Italy.

Several recent studies have reported the detection of an anomalous color spread along the red giant branch (RGB) of some globular clusters (GC) that appears only when color indices including a near ultraviolet band (such as Johnson U or Strmgren u) are considered. This anomalous spread in color indexes such as U-B or $c_y$ has been shown to correlate with variations in the abundances of light elements such as C, N, O, Na, etc., which, in turn, are generally believed to be associated with subsequent star formation episodes that occurred in the earliest few $10^8$ yr of the cluster's life. Here we use publicly available u, g, r Sloan Digital Sky Survey photometry to search for anomalous u-g spreads in the RGBs of nine Galactic GCs. In seven of them (M 2, M 3, M 5, M 13, M 15, M 92 and M 53), we find evidence of a statistically significant spread in the u-g color, not seen in g-r and not accounted for by observational effects. In the case of M 5, we demonstrate that the observed u-g color spread correlates with the observed abundances of Na, the redder stars being richer in Na than the bluer ones. In all the seven clusters displaying a significant u-g color spread, we find that the stars on the red and blue sides of the RGB, in (g, u-g) color magnitude diagrams, have significantly different radial distributions. In particular, the red stars (generally identified with the second generation of cluster stars, in the current scenario) are always more centrally concentrated than blue stars (generally identified with the first generation) over the range sampled by the data ($0.5\ r_h < r < 5\ r_h$), in qualitative agreement with the predictions of some recent models of the formation and chemical evolution of GCs. Our results suggest that the difference in the radial distribution between first and second generation stars may be a general characteristic of GCs.

**Accepted by : Astronomy & Astrophysics**
*For preprints, contact* `carmela.lardo2@unibo.it`
*Also available from the URL* `http://arxiv.org/abs/1010.4697`
*or by anonymous ftp at* `ftp://`

.....

# Fundamental parameters, integrated RGB mass loss and dust production in the Galactic globular cluster 47 Tucanae

**Iain McDonald ([1]), M. L. Boyer ([2]), J. Th. van Loon ([3]), A. A. Zijlstra ([1]), J. L. Hora [9]4), B. Babler ([5]), M. Block ([6]), K. Gordon ([2]), M. Meade ([5]), M. Meixner ([2]), K. Misselt ([6]), T. Robitaille ([4]), M. Sewilo ([2]), B. Shiao ([2]), B. Whitney([2])**

([1]) Jodrell Bank Centre for Astrophysics, Alan Turing Building, Manchester, M13 9PL, UK; ([2]) STScI, 3700 San Martin Drive, Baltimore, MD 21218, USA; ([3]) Lennard-Jones Laboratories, Keele University, ST5 5BG, UK; ([4]) Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS [6]5, Cambridge, MA 02138-1516, USA; ([5]) Department of Astronomy, University of Wisconsin, Madison, [4]75 North Charter Street, Madison, WI 53706-1582, USA; ([6]) Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tuscon, AZ 85721, USA

Fundamental parameters and time-evolution of mass loss are investigated for post-main-sequence stars in the Galactic globular cluster 47 Tucanae (NGC 104). This is accomplished by fitting spectral energy distributions (SEDs) to existing optical and infrared photometry and spectroscopy, to produce a true Hertzsprung-Russell diagram. We confirm the cluster's distance as d = 4611 (+213/-200) pc and age as 12 $\pm$ 1 Gyr. Horizontal branch models appear to confirm that no more RGB mass loss occurs in 47 Tuc than in the more-metal-poor omega Centauri, though difficulties arise due to inconsistencies between the models. Using our SEDs, we identify those stars which exhibit infrared excess, finding excess only among the brightest giants: dusty mass loss begins at a luminosity of $\sim$1000 $L_\odot$, becoming ubiquitous above L = 2000 $L_\odot$. Recent claims of dust production around lower-luminosity giants cannot be reproduced, despite using the same archival Spitzer imagery.

**Accepted by : Astrophysical Journal Supplement Series**
*For preprints, contact* `mcdonald@jb.man.ac.uk`
*Also available from the URL* `http://xxx.soton.ac.uk/abs/1101.1095`
*or by anonymous ftp at* `ftp://`

. . . . . .

# Dust production and mass loss in the Galactic globular cluster 47 Tucanae

**Iain McDonald ([1]), M. L. Boyer ([2]), J. Th. van Loon ([3]), A. A. Zijlstra ([1])**

([1]) Jodrell Bank Centre for Astrophysics, Alan Turing Building, Manchester, M13 9PL, UK; ([2]) STScI, 3700 San Martin Drive, Baltimore, MD 21218, USA; ([3]) Lennard-Jones Laboratories, Keele University, ST5 5BG, UK

Dust production among post-main-sequence stars is investigated in the Galactic globular cluster 47 Tucanae (NGC 104) based on infrared photometry and spectroscopy. We identify metallic iron grains as the probable dominant opacity source in these winds. Typical evolutionary timescales of AGB stars suggest the mass-loss rates we report are too high. We suggest that this is because the iron grains are small or elongated and/or that iron condenses more efficiently than at solar metallicity. Comparison to other works suggests metallic iron is observed to be more prevalent towards lower metallicities. The reasons for this are explored, but remain unclear. Meanwhile, the luminosity at which dusty mass loss begins is largely invariant with metallicity, but its presence correlates strongly with long-period variability. This suggests that the winds of low-mass stars have a significant driver that is not radiation pressure, but may be acoustic driving by pulsations.

**Accepted by : Astrophysical Journal**

*For preprints, contact* `mcdonald@jb.man.ac.uk`

*Also available from the URL* `http://xxx.soton.ac.uk/abs/1101.1096`

*or by anonymous ftp at* `ftp://`

. . . . . .

# Distant star clusters of the Milky Way in MOND

**H. Haghi[1], H. Baumgardt[2], P. Kroupa[3]**
[1]IASBS, Zanjan, Iran, [2]University of Queensland, Australia, [3]AIfA, University of Bonn, Germany

We determine the mean velocity dispersion of six Galactic outer halo globular clusters, AM 1, Eridanus, Pal 3, Pal 4, Pal 15, and Arp 2 in the weak acceleration regime to test classical vs. modified Newtonian dynamics (MOND). Owing to the non-linearity of MOND's Poisson equation, beyond tidal effects, the internal dynamics of clusters is affected by the external field in which they are immersed. For the studied clusters, particle accelerations are much lower than the critical acceleration a0 of MOND, but the motion of stars is neither dominated by internal accelerations ($a_i \gg a_e$) nor external accelerations ($a_e \gg a_i$). We use the N-body code N-MODY in our analysis, which is a particle-mesh-based code with a numerical MOND potential solver developed by Ciotti, Londrillo, and Nipoti (2006) to derive the line-of-sight velocity dispersion by adding the external field effect. We show that Newtonian dynamics predicts a low-velocity dispersion for each cluster, while in modified Newtonian dynamics the velocity dispersion is much higher. We calculate the minimum number of measured stars necessary to distinguish between Newtonian gravity and MOND with the Kolmogorov-Smirnov test. We also show that for most clusters it is necessary to measure the velocities of between 30 to 80 stars to distinguish between both cases. Therefore the observational measurement of the line-of-sight velocity dispersion of these clusters will provide a test for MOND.

**Accepted by: Astronomy & Astrophysics**
*For preprints, contact* h.baumgardt@uq.edu.au
*Also available from the URL* http://arxiv.org/abs/1101.1952
*or by anonymous ftp at*

. . . . . .

# 4. Galactic Center Clusters

## Stellar Dynamics of Extreme-Mass-Ratio Inspirals

**David Merritt, Tal Alexander, Seppo Mikkola, Clifford Will**
RIT, Weizmann Institute, Tuorla Observatory, Washington University

Inspiral of compact stellar remnants into massive black holes (MBHs) is accompanied by the emission of gravitational waves at frequencies that are potentially detectable by the proposed laser interferometer space antenna. Event rates computed from statistical (Fokker-Planck, Monte-Carlo) approaches span a wide range due to uncertaintities about the rate coefficients. Here we present results from direct integration of the post-Newtonian N-body equations of motion descrbing dense clusters of compact stars around Schwarzschild and Kerr MBHs. These simulations embody an essentially exact (at the post-Newtonian level) treatment of the interplay between stellar dynamical relaxation, relativistic precession, and gravitational-wave energy loss. The rate of capture of stars by the MBH is found to be greatly reduced by relativistic precession, which limits the ability of torques from the stellar potential to change orbital angular momenta. Penetration of this Schwarzschild barrier does occasionally occur, resulting in capture of stars onto orbits that gradually inspiral due to gravitational wave emission; we discuss two mechanisms for barrier penetration and find evidence for both in the simulations. We derive an approximate formula for the capture rate, which predicts that captures would be strongly disfavored from orbits with semi-major axes below a certain value; this prediction, as well as the predicted rate, are verified in the N-body integrations. Adding spin to the MBH does not substantially change the capture rate; the back-reaction of the stellar torques on the spin of the MBH is evaluated and shown to be potentially observable. We discuss the implications of our results for the detection of extreme-mass-ratio inspirals from galactic nuclei with a range of physical properties.

**To appear in : The Physical Review**
*For preprints, contact*
*Also available from the URL* `http://`
*or by anonymous ftp at* `ftp://`

. . . . . .

# 5. Extragalactic Clusters

## A New Method for the Assessment of Age and Age Spread of Pre-main-sequence Stars in Young Stellar Associations of the Magellanic Clouds

**Da Rio, Nicola; Gouliermis, Dimitrios A.; Gennaro, Mario**
Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

We present a new method for the evaluation of the age and age spread among pre–main-sequence (PMS) stars in star-forming regions in the Magellanic Clouds, accounting simultaneously for photometric errors, unresolved binarity, differential extinction, stellar variability, accretion, and crowding. The application of the method is performed with the statistical construction of synthetic color-magnitude diagrams (CMDs) using isochrones from two families of PMS evolutionary models. We convert each isochrone into two-dimensional probability distributions of artificial PMS stars in the CMD by applying the aforementioned biases that dislocate these stars from their original CMD positions. A maximum-likelihood technique is then applied to derive the probability for each observed star to have a certain age as well as the best age for the entire cluster. We apply our method to the photometric catalog of ∼2000 PMS stars in the young association LH 95 in the Large Magellanic Cloud, based on the deepest HST/ACS imaging ever performed toward this galaxy, with a detection limit of V ∼ 28, corresponding to M ∼ 0.2 $M_{\odot}$. We assume the initial mass function and reddening distribution for the system, as they have been previously derived by us. Our treatment shows that the age determination is very sensitive to the considered grid of evolutionary models and the assumed binary fraction. The age of LH 95 is found to vary from 2.8 Myr to 4.4 Myr, depending on these factors. We evaluate the accuracy of our age estimation and find that the method is fairly accurate in the PMS regime, while the precision of the measurement of the age is lower at higher luminosities. Our analysis allows us to disentangle a real age spread from the apparent CMD broadening caused by the physical and observational biases. We find that LH 95 hosts an age spread that is represented well by a Gaussian distribution with an FWHM of the order of 2.8-4.4 Myr depending on the model and binary fraction. We detect a dependence of the average age of the system with the stellar mass. This dependence does not appear to have any physical meaning, being rather due to imperfections of the PMS evolutionary models, which tend to predict lower ages for the intermediate-mass and higher ages for the low-mass stars.

**To appear in : Published in the Astrophysical Journal, Volume 723, Issue 1, pp. 166-183 (2010)**
*For preprints, contact* `dgoulier@mpia.de`
*Also available from the URL* `http://iopscience.iop.org/0004-637X/723/1/166/`
*or by anonymous ftp at* `ftp://`

.....

# Hierarchical Stellar Structures in the Local Group Dwarf Galaxy NGC 6822

**Gouliermis, Dimitrios A. ([1]); Schmeja, Stefan ([2]); Klessen, Ralf S. ([2]); de Blok, W. J. G. ([3]); Walter, Fabian ([1])**

([1]) Max Planck Institute for Astronomy, Koenigstuhl 17, 69117 Heidelberg, Germany; ([2]) Zentrum fuer Astronomie der Universitaet Heidelberg, Institut fuer Theoretische Astrophysik, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany; ([3]) University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa;

We present a comprehensive study of the star cluster population and the hierarchical structure in the clustering of blue stars with ages $< 500$ Myr in the Local Group dwarf irregular galaxy NGC 6822. Our observational material comprises the most complete optical stellar catalog of the galaxy from imaging with the Suprime-Cam at the 8.2-m SUBARU Telescope. We identify 47 distinct star clusters with the application of the nearest-neighbor density method to this catalog for a detection threshold of 3sigma above the average stellar density. The size distribution of the detected clusters can be very well approximated by a Gaussian with a peak at$t \sim 68$ pc. Their cluster mass function is fitted very well by a power-law with index alpha $\sim 1.5 \pm 0.7$, consistent with other Local Group galaxies and the cluster initial mass function. The application of the nearest-neighbor density method for various density thresholds, other than 3sigma, enabled the identification of stellar concentrations in various length-scales. The stellar density maps constructed with this technique provide a direct proof of hierarchically structured stellar concentrations in NGC 6822. We illustrate this hierarchy by the so-called "dendrogram" of the detected stellar structures, which demonstrates that most of the detected structures split up into several substructures over at least three levels. We quantify the hierarchy of these structures with the use of the minimum spanning tree method. The morphological hierarchy in stellar clustering, which we observe in NGC 6822 resembles that of the turbulent interstellar matter, suggesting that turbulence on pc- and kpc-scales has been probably the major agent that regulated clustered star formation in NGC 6822.

**Accepted by : Astrophysical Journal**
*For preprints, contact* `dgoulier@mpia.de`
*Also available from the URL* `http://adsabs.harvard.edu/abs/2010arXiv1010.1940G`
*or by anonymous ftp at* `ftp://`

.....

# Assessment of Stellar Stratification in Three Young Star Clusters in the Large Magellanic Cloud

**Gouliermis, Dimitrios A. ([1]); Mackey, Dougal ([2]); Xin, Yu ([3]); Rochau, Boyke ([1])**

([1]) Max Planck Institute for Astronomy, Koenigstuhl 17, 69117 Heidelberg, Germany; ([2]) Institute for Astronomy, University of Edinburgh, Royal Observatory, Blackford Hill, Edinburgh, EH9 3HJ, UK; ([3]) Argelander Institut fuer Astronomie, Rheinische Friedrich-Wilhelms-Universitaet Bonn, Auf dem Huegel 71, 53121 Bonn, Germany

We present a comprehensive study of stellar stratification in young star clusters in the Large Magellanic Cloud (LMC). We apply our recently developed effective radius method for the assessment of stellar stratification on imaging data obtained with the Advanced Camera for Surveys of three young LMC clusters to characterize the phenomenon and develop a comparative scheme for its assessment in such clusters. The clusters of our sample, NGC 1983, NGC 2002, and NGC 2010, are selected on the basis of their youthfulness, and their variety in appearance, structure, stellar content, and surrounding stellar ambient. Our photometry is complete for magnitudes down to $m_{814} \sim 23$ mag, allowing the calculation of the structural parameters of the clusters, the estimation of their ages, and the determination of their stellar content. Our study shows that each cluster in our sample demonstrates stellar stratification in a quite different manner and at different degree from the others. Specifically, NGC 1983 shows partial segregation, with the effective radius increasing with fainter magnitudes only for the faintest stars of the cluster. Our method on NGC 2002 provides evidence of strong stellar stratification for both bright and faint stars; the cluster demonstrates the phenomenon with the highest degree in the sample. Finally, NGC 2010 is not segregated, as its bright stellar content is not centrally concentrated, the relation of effective radius to magnitude for stars of intermediate brightness is rather flat, and we find no evidence of stratification for its faintest stars. For the parameterization of the phenomenon of stellar stratification and its quantitative comparison among these clusters, we propose the slope derived from the change in the effective radius over the corresponding magnitude range as indicative parameter of the degree of stratification in the clusters. A positive value of this slope indicates mass segregation in the cluster, while a negative or zero value signifies the lack of the phenomenon.

**To appear in : Published in the Astrophysical Journal, Volume 709, Issue 1, pp. 263-277 (2010)**

*For preprints, contact* dgoulier@mpia.de

*Also available from the URL* http://iopscience.iop.org/0004-637X/709/1/263/

*or by anonymous ftp at* ftp://

.....

# 6. Dynamical evolution - Simulations

## Calibration of radii and masses of open clusters with a simulation

**Ernst, A. ([1]), Just, A. ([1]), Berczik, P. ([1,2,3]), Petrov M. I. ([4])**

([1]) Astronomisches Rechen-Institut am Zentrum für Astronomie der Univ. Heidelberg; ([2]) National Astronomical Observatories of China, Beijing; ([3]) Main Astronomical Observatory, National Academy of Sciences of Ukraine, Kyiv; ([4]) Institut fr Astronomie der Universität Wien

Context: A recent new approach to apply a simple dynamical mass estimate of tidally limited star clusters is based on the identification of the tidal radius in a King profile with the dynamical Jacobi radius. The application to an unbiased open cluster catalogue yields significantly higher cluster masses compared to the classical methods. Aims: We quantify the bias in the mass determination as function of projection direction and cluster age by analysing a simulated star cluster. Methods: We use direct $N$-body simulations of a star cluster including stellar evolution in an analytic Milky Way potential and apply a best fit to the projected number density of cluster stars. Results: We obtain significantly overestimated star cluster masses which depend strongly on the viewing direction. The overestimation is typically in the range of 10-50 percent and reaches a factor of 3.5 for young clusters. Mass segregation reduces the derived limiting radii systematically.

**Accepted by : Astronomy & Astrophysics**
*For preprints, contact* `aernst@ari.uni-heidelberg.de`
*Also available from the URL* `http://arxiv.org/abs/1009.0710`
*or by anonymous ftp at* `ftp://`

.....

## The life cycle of star cluster in a tidal field

**Mark Gieles ([1]), Douglas C. Heggie ([2]) and HongSheng Zhao ([3])**
([1]) Cambridge ([2]) Edinburgh ([3]) St. Andrews

The evolution of globular clusters due to 2-body relaxation results in an outward flow of energy and at some stage all clusters need a central energy source to sustain their evolution. Henon provided the insight that we do not need to know the details of the energy production in order to understand the relaxation-driven evolution of the cluster, at least outside the core. He provided two self-similar solutions for the evolution of clusters based on the view that the cluster as a whole determines the amount of energy that is produced in the core: steady expansion for isolated clusters, and homologous contraction for clusters evaporating in a tidal field. We combine these models: the half-mass radius increases during the first half of the evolution, and decreases in the second half; while the escape rate approaches a constant value set by the tidal field. We refer to these phases as 'expansion dominated' and 'evaporation dominated'. These simple analytical solutions immediately allow us to construct evolutionary tracks and isochrones in terms of cluster half-mass density, cluster mass and galactocentric radius. From a comparison to the Milky Way globular clusters we find that roughly 1/3 of them are in the second, evaporation-dominated phase and for these clusters the density inside the half-mass radius varies with the galactocentric distance R as $\rho_h \sim 1/R^2$. The remaining 2/3 are still in the first, expansion-dominated phase and their isochrones follow the environment-independent scaling $\rho_h \sim M^2$; that is, a constant relaxation time-scale. We find substantial agreement between Milky Way globular cluster parameters and the isochrones, which suggests that there is, as Henon suggested, a balance between the flow of energy and the central energy production for almost all globular clusters.

**Accepted by : Monthly Notices of the Royal Astronomical Society**
*For preprints, contact* `mgieles@ast.cam.ac.uk`
*Also available from the URL* `http://arxiv.org/abs/1101.1821`
*or by anonymous ftp at* `ftp://`

.....

## The role of stellar collisions for the formation of massive stars

**H. Baumgardt[1], R. Klessen[2]**
[1]University of Queensland, Australia, [2]University of Heidelberg, Germany

We use direct N-body simulations of gas embedded star clusters to study the importance of stellar collisions for the formation and mass accretion history of high-mass stars. Our clusters start in virial equilibrium as a mix of gas and proto-stars. Proto-stars then accrete matter using different mass accretion rates and the amount of gas is reduced in the same way as the mass of stars increases. During the simulations we check for stellar collisions and we investigate the role of these collisions for the build-up of high-mass stars and the formation of runaway stars. We find that a significant number of collisions only occur in clusters with initial half-mass radii $r_h < 0.1$ pc. After emerging from their parental gas clouds, such clusters end up too compact compared to observed young, massive open clusters. In addition, collisions lead mainly to the formation of a single runaway star instead of the formation of many high mass stars with a broad mass spectrum. We therefore conclude that massive stars form mainly by gas accretion, with stellar collisions only playing a minor role if any at all. Collisions of stars in the pre-main sequence phase might however contribute to the formation of the most massive stars in the densest star clusters and possibly to the formation of intermediate-mass black holes with masses up to a few 100 $M_\odot$.

**Accepted by: Monthly Notices of the Royal Astronomical Society**
*For preprints, contact* `h.baumgardt@uq.edu.au`
*Also available from the URL* `http://arxiv.org/abs/1009.1189`
*or by anonymous ftp at*

. . . . . .

# 7. Miscellaneous

## The Galactic O-Star Spectroscopic Survey. I. Classification System and Bright Northern Stars in the Blue-Violet at R∼2500

**A. Sota, J. Maíz Apellániz, N. R. Walborn, E. J. Alfaro, R. H. Barb, N. I. Morrell, R. C. Gamen, & J. I. Arias**

IAA-CSIC, IAA-CSIC, STScI, IAA-CSIC, ULS, LCO, IALP-CONICET, ULS

We present the first installment of a massive spectroscopic survey of Galactic O stars, based on new, high signal-to-noise ratio, R∼2500 digital observations from both hemispheres selected from the Galactic O-Star Catalog of Maáz Apellániz et al. (2004) and Sota et al. (2008). The spectral classification system is rediscussed and a new atlas is presented, which supersedes previous versions. Extensive sequences of exceptional objects are given, including types Ofc, ON/OC, Onfp, Of?p, Oe, and double-lined spectroscopic binaries. The remaining normal spectra bring this first sample to 184 stars, which is close to complete to B=8 and north of delta = -20 and includes all of the northern objects in Maáz Apellániz et al. (2004) that are still classified as O stars. The systematic and random accuracies of these classifications are substantially higher than previously attainable, because of the quality, quantity, and homogeneity of the data and analysis procedures. These results will enhance subsequent investigations in Galactic astronomy and stellar astrophysics. In the future we will publish the rest of the survey, beginning with a second paper that will include most of the southern stars in Maíz Apellániz et al. (2004).

**Accepted by : Astrophysical Journal Supplement Series**
*For preprints, contact* `jmaiz@iaa.es`
*Also available from the URL* `http://arxiv.org/abs/1101.4002`
*or by anonymous ftp at*

. . . . . .

## New discussion group about star cluster research

This announcement is to make the readers of SCYON aware that I have set up a group on CiteULike (a web facility for searching, organizing, and sharing academic papers), devoted to collect preprints & papers about stellar clusters. You can find it at the following address:

http://www.citeulike.org/group/6906

Citeulike is based on the principle of social bookmarking and is aimed to promote and to develop the sharing of scientific references amongst researchers. In the same way that it is possible to catalog web pages (with Furl and del.icio.us) or photographs (with Flickr), scientists can share information on academic papers with specific tools (like CiteULike) developed for that purpose (from wikipedia's entry, http://en.wikipedia.org/wiki/CiteULike)

Every person that belongs to the group can post links to published papers and preprints. Each posted article will appear in the library of the group (where a wide range of options will be available, such as searching, commenting, rating, importing in a personal library, use the group forum or message board, etc...).

Posting to the group is rather straightforward since many websites already display the caracteristic 'blue button' to post to CiteULike (as an example, posting an article to CiteULike from astro-ph or from the Astronomy & Astrophysics website is nearly a one click matter).

A free registration is required in order to use all the features of the groups; at any rate, no autentication is needed to browse the group library.

Below are some direct links to the main areas of the groups (not all equally populated at the moment):

Homepage:
http://www.citeulike.org/groupfunc/6906/home

Library of paper:
http://www.citeulike.org/group/6906

Messages:
http://www.citeulike.org/groupfunc/6906/messages

Forums Threads:
http://www.citeulike.org/groupfunc/6906/forums

Group Blog:
http://www.citeulike.org/groupblog/6906

Using an existing web service (instead of building one from scratch) has allowed me to use the (excellent) architecture of the application, focusing only on the group configuration. The price to pay, as it happens in these cases, is that we both have to tolerate a certain degree of advertising. :-)

I just hope that this web facility will be useful to facilitate connections among the community of people who work on the fascinating field of stellar clusters. In particular, I hope the group will reveal itself as an useful tool for users of WEBDA (http://www.univie.ac.at/webda/) and of the Globular Clusters database (http://gclusters.altervista.org), as well as for people that follow this newsletter.

For any question about the Stellar Cluster CiteULike group, please do not hesitate to contact me.

Marco Castellani
INAF - Rome Astronomical Observatory
m.castellani@oa-roma.inaf.it

# The Next Generation Virgo Cluster Survey Infrared (NGVS-IR) Postdoctoral Fellowship

## Pontificia Universidad Catolica de Chile, Santiago, Chile

Applications are invited for a post-doctoral fellow position in infrared astronomy at the Department of Astronomy and Astrophysics of Pontificia Universidad Catolica de Chile (DAA-PUC). The successful candidate will pursue projects with Prof. Thomas H. Puzia based on data from the Next Generation Virgo Cluster Survey-IR (http://goo.gl/72LoG). The survey provides the near-IR counterpart to the recently completed pilot program of the Next Generation Virgo Survey (http://goo.gl/5eAe5). It covers the central 4 square degrees of the Virgo cluster with a depth in Ks that exceeds that of UKIDSS by 3 magnitudes (possibly more). Ongoing data reduction confirms that the images are of exquisite quality. The postdoctoral fellow will be expected to contribute actively to the scientific exploitation of these data. The focus of projects could be on the immense population of star clusters and other compact objects detected in the field. However, other topics can be considered (e.g. stellar population maps of Virgo galaxies, distant galaxy clusters, Galactic streams, etc.).

Candidates should have a PhD in astronomy, astrophysics, or related disciplines. A preference will be given to candidates with a strong background in optical, IR, and/or sub-millimeter astronomy and thorough experience in astronomical data reduction as well as solid mathematical background in statistics.

DAA-PUC provides a vibrant and productive international environment with 15 faculty and 13 postdocs, and about 30 graduate students. While resident at DAA-PUC the candidate will qualify as a member of the Chilean community and therefore will have direct access to 10% of observing time on all telescopes in Chile, including ESO/Paranal's $4 \times 8$m VLT and 4m VISTA, La Sillas 3.5m NTT and the 3.6m and 2.2m telescopes, Gemini-South 8m, Carnegie's 2.5m and Magellan $2 \times 6.5$m, CTIO's 4m (Blanco), SOAR 4m, as well as ASTE, APEX, and "Early-Science"-ALMA. Additionally, DAA-PUC hosts a 512-core supercomputer which is used for numerical simulations and work with large databases, to which the candidate will have full access.

The appointment is for two years starting as early as summer 2011, with a possibility of extension based on performance and availability of funding. Applicants should send (electronically and in pdf format) a cover letter, CV, publication list, a statement of research interests highlighting potential own research projects based on the NGVS(-IR) survey, and arrange for three letters of recommendation to be sent directly by email to Prof. Puzia (tpuzia@gmail.com). Applications received before April 30th, 2011 will receive full consideration, but late applications will be welcome until the position is filled.

DAA-PUC is committed to employment equity.

. . . . . .