$\mathcal{SCYON}$

The Star Clusters Young & Old Newsletter

edited by Holger Baumgardt, Ernst Paunzen and Pavel Kroupa

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

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EDITORIAL

This is the 43rd issue of the SCYON newsletter. Todays issue is one of the few where we got submissions for nearly all the sections. In total we have 16 abstracts from refereed publications, and PhD summaries by Remco Scheepmaker (Utrecht) and Andreas Ernst (Heidelberg). We also have announcements for conferences in Leiden and Prague in September/October this year and a job announcement for several PhD positions at Leiden Observatory.

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

Holger Baumgardt, Ernst Paunzen and Pavel Kroupa

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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.

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

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

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

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

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

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

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

The editors

SCYON Mirrors

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

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1. Star Forming Regions

HIERARCHICAL STAR FORMATION IN THE MILKY WAY DISK

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Hierarchical star formation leads to a progressive decrease in the clustering of star clusters both in terms of spatial scale and age. Consistently, statistical analysis of the positions and ages of clusters in the Milky Way disk strongly suggests that a correlation between the duration of star formation in a region and its size does exist. The average age difference between pairs of open clusters increases with their separation as the ∼0.16 power. In contrast, for the Large Magellanic Cloud, Efremov & Elmegreen found that the age difference scales with the ∼0.35 power of the region size. This discrepancy may be tentatively interpreted as an argument in support of intrinsically shorter (faster) star formation timescales in smaller galaxies. However, if both the effects of cluster dissolution and incompleteness are taken into consideration, the average age difference between cluster pairs in the Galaxy increases with their separation as the ∼0.4 power. This result implies that the characteristic timescale for coherent, clustered-mode star formation is nearly 1 Myr. Therefore, the overall consequence of ignoring the effect of cluster dissolution is to overestimate the star formation timescale. On the other hand, in the Galactic disk and for young clusters separated by less than three times the characteristic cluster tidal radius (10 pc), the average age difference is 16 Myr, which suggests common origin. A close pair classification scheme is introduced and a list of 11 binary cluster candidates with physical separation less than 30 pc is compiled. Two of these pairs are likely primordial: ASCC 18/ASCC 21 and NGC 3293/NGC 3324. A triple cluster candidate in a highly hierarchical configuration is also identified: NGC 1981/NGC 1976/Collinder 70 in Orion. We find that binary cluster candidates seem to show a tendency to have components of different size evidence for dynamical interaction.

To appear in : R. de la Fuente Marcos et al 2009 ApJ 700 436-446 doi: 10.1088/0004-637X/700/1/436

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2. Galactic Open Clusters

A study of the Galactic plane towards l = 305°

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We present optical (UBVIc) observations of a rich and complex field in the Galactic plane towards l $\sim 305°$ and b $\sim 0°$. Our analysis reveals a significantly high interstellar absorbtion (Av ~ 10) and an abnormal extinction law in this line of sight. Availing a considerable number of color combinations, the photometric diagrams allow us to derive new estimates of the fundamental parameters of the two open clusters Danks 1 and Danks 2. Due to the derived abnormal reddening law in this line of sight, both clusters appear much closer (to the Sun) than previously thought. Additionally, we present the optical colors and magnitudes of the WR 48a star and its main parameters were estimated. The properties of the two embedded clusters DBS2003 130 and 131, are also addressed. We identify a number of Young Stellar Objects which are probable members of these clusters. This new material is then used to revisit the spiral structure in this sector of the Galaxy showing evidence of populations associated with the inner Galaxy Scutum-Crux arm.

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Old open clusters in the Sagittarius dSph tidal stream – kith or kin?

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A widely supported formation scenario for the Galactic disc is that it formed inside-out from material accumulated via accretion events. The Sagittarius dwarf spheroidal galaxy (Sgr dSph) is the best example of a such accretion, and its ongoing disruption has resulted in that its stars are being deposited in the Milky Way halo and outer disc. It is therefore appealing to search for possible signatures of the Sgr dSph contribution to the build-up of the Galactic disc. Interestingly, models of the Sgr dSph stream indicate clearly that the trailing tail passes through the outer Galactic disc, at the same galactocentric distance as some anti-centre old open star clusters. We investigate in this Letter the possibility that the two outermost old open clusters, Berkeley 29 and Saurer 1, could have formed inside the Sgr dSph and then left behind in the outer Galactic disc as a result of tidal interaction with the Milky Way. The actual location of these two star clusters, inside the Sgr dSph trailing tail, is compatible with this scenario, and their chemical and kinematical properties, together with our present understanding of the age-metallicity relationship in the Sgr dSph, lends further support to this possible association. Hence, we find it likely that the old open star clusters Berkeley 29 and Saurer 1 have extra-galactic origins.

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Double or binary: on the multiplicity of open star clusters

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Context. Observations indicate that the fraction of potential binary star clusters in the Magellanic Clouds is about 10%. In contrast, it is widely accepted that the binary cluster frequency in the Galaxy disk is much lower.

Aims. Here we investigate the multiplicity of clusters in the Milky Way disk to either confirm or disprove this dearth of binaries.

Methods. We quantify the open cluster multiplicity using complete, volume-limited samples from WEBDA and NCOVOCC.

Results. At the Solar Circle, at least 12% of all open clusters appear to be experiencing some type of interaction with another cluster; i.e., are possible binaries. As in the Magellanic Clouds, the pair separation histogram hints at a bimodal distribution. Nearly 40% of identified pairs are probably primordial. Most of the remaining pairs could be undergoing some type of close encounter, perhaps as a result of orbital resonances. Confirming early theoretical predictions, the characteristic time scale for destruction of bound pairs in the disk is 200 Myr, or one galactic orbit.

Conclusions. Our results show that the fraction of possible binary clusters in the Galactic disk is comparable to that in the Magellanic Clouds.

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Characteristics of the Galaxy according to Cepheids (& Young Open Clusters)

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Classical and Type II Cepheids are used to reinvestigate specific properties of the Galaxy. A new Type II reddening-free Cepheid distance parameterization is formulated from LMC Cepheids (OGLE), with uncertainties typically no larger than 5-15%. A distance to the Galactic centre of R0=7.8+-0.6 kpc is derived from the median distance to Type II Cepheids in the bulge (OGLE), R0=7.7+-0.7 kpc from a distance to the near side of the bulge combined with an estimated bulge radius of 1.3+-0.3 kpc derived from planetary nebulae. The distance of the Sun from the Galactic plane inferred from classical Cepheid variables is Zsun=26+-3 pc, a result dependent on the sample's distance and direction because of the complicating effects of Gould's Belt and warping in the Galactic disk. Classical Cepheids and young open clusters delineate consistent and obvious spiral features, although their characteristics do not match conventional pictures of the Galaxy's spiral pattern. The Sagittarius-Carina arm is confirmed as a major spiral arm that appears to originate from a different Galactic region than suggested previously. Furthermore, a major feature is observed to emanate from Cygnus-Vulpecula and may continue locally near the Sun. Significant concerns related to the effects of metallicity on the VI-based reddening-free Cepheid distance relations used here are allayed by demonstrating that the computed distances to the Galactic centre, and to several globular clusters (M54, NGC 6441, M15, and M5) and galaxies (NGC 5128 and NGC 3198) which likely host Type II Cepheids: agree with literature results to within the uncertainties.

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Homogeneous photometry and star counts in the field of 9 Galactic star clusters

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We present homogeneous V, I CCD photometry of nine stellar fields in the two i nner quadrants of the Galactic plane. The lines-of-view to most of these fields aim in the dire ction of the very inner Galaxy, where the Galactic field is very dense, and extinction is high and patchy. Our nine fields are, according to several catalogs, centred on Galactic star cluster s, namely Trumpler 13, Trumpler 20, Lynga 4, Hogg 19, Lynga 12, Trumpler 25, Trumpler 26, Ruprecht 128, and Trumpler 34. Apart from their coordinates, and in some cases a dditional basic data (mainly from the 2MASS archive), their properties are poorly known. B y means of star count techniques and field star decontaminated Color-Magnitude diagrams, the nat ure and size of these visual over-densities has been established; and, when possible, new cluste r fundamental parameters have been derived. To strengthen our findings, we complement our data -set with JHK_s photometry from the 2MASS archive, that we analyze using a suitably defined Q-parameter.
Most clusters are projected towards the Carina-Sagittarium spiral arm. Because of that, we detect in the Color Magnitude Diagrams of most of the other fields several distinctive sequences produced by young popu lation within the arm. All the clusters are of intermediate or old age. The most interesting cases detected by our study are, perhaps, that of Trumpler 20, which seems to be much older than previously believed, as indicated by its promi nent -and double- red clump; and that of Hogg 19, a previously overlooked old open cluster, whose existence in such regions of the Milky Way is puzzling.

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The Cepheid Impostor HD 18391 and its Anonymous Parent Cluster

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New and existing photometry for the G0 Ia supergiant HD 18391 is analyzed in order to confirm the nature of the variablity previously detected in the star, which lies off the hot edge of the Cepheid instability strip. Small-amplitude variability at a level of ΔV = 0.016+-0.002 is indicated, with a period of P=123.04+-0.06 d. A weaker second signal may be present at P=177.84+-0.18 with ΔV = 0.007+-0.002, likely corresponding to fundamental mode pulsation if the primary signal represents overtone pulsation (123.04/177.84 = 0.69). The star, with a spectroscopic reddening of E(B-V) = 1.02, is associated with heavily-reddened B-type stars in its immediate vicinity that appear to be outlying members of an anonymous young cluster centered ∼10 arcmin to the west and 1661+-73 pc distant. The cluster has nuclear and coronal radii of $r_n = 3.5$ arcmin and $R_c = 14$ arcmin, respectively, while the parameters for HD 18391 derived from membership in the cluster with its outlying B stars are consistent with those implied by its Cepheid-like pulsation, provided that it follows the semi-period-luminosity relation expected of such objects. Its inferred luminosity as a cluster member is M_V=-7.76+-0.10, its age (9+-1)x10^6 years, and its evolutionary mass ∼19 $M_\odot$. HD 18391 is not a classical Cepheid, yet it follows the Cepheid period-luminosity relation closely, much like another Cepheid impostor, V810 Cen.

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A spectroscopic study of the Open Cluster NGC 6475 (M 7). Chemical Abundances from stars in the range T_{eff}= 4500-10000 K

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Clusters of stars are key objects for the study of the dynamical and chemical evolution of the Galaxy and its neighbors. In particular chemical composition is obtained from different kinds of stars (hot main-sequence stars, cool main-sequence stars, horizontal-branch stars, RGB stars) using different methodologies. Our aim is to apply these methodologies to the stars of the Open Cluster NGC 6475. Obtaining a census of the most important elements we will be able to test their consistence. We finally want to establish more robust fundamental parameters for this cluster.We selected high S/N high resolution spectra of 7 stars of the Open Cluster NGC 6475 from the ESO database covering the T_{eff} range 4500-10000 K and of luminosity class V (dwarf) and III (giants). We determined the chemical abundances of several elements. For hot stars (T_{eff}>9000 K) we applied the Balmer Lines fitting method to obtained atmospheric parameters. For cool stars (T_{eff}<6500 K) we used the FeI/II abundance equilibrium method. For the two groups of stars the use of different line-lists was mandatory. LTE approximation was used. For elements affected by NLTE deviation (C,N,O,Na,Mg) corrections were applied. The abundance of many elements were obtained from the measurement of the equivalent width of spectral lines. For those elements for which only blended lines were available (O, He) comparison of real spectrum with synthetic ones was used. Hyperfine structure was taken in account for V and Ba.First of all we showed that the two methodologies we used give abundances which are in agreement within the errors. This implies that no appreciable relative systematic effects are present for the derived chemical content of cool and hot stars. On the other hand giants stars show clear chemical peculiarities with respect the dwarf concerning light elements (up to Si) and maybe Ba. This fact can be explained as an evolutionary effect. Then, having a new estimation of the metallicity for the cluster ([Fe/H]=+0.03±0.02, [α/Fe]=-0.06±0.02) we fitted suitable isochrones to the CMD of the cluster obtaining the basic parameters (E(B-V)=0.08±0.02, $(m-M)_0$=7.65±0.05, Age=200±50

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3. Galactic Center Clusters

On the dissolution of star clusters in the Galactic centre. I. Circular orbits

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We present N-body simulations of dissolving star clusters close to galactic centres. For this purpose, we developed a new N-body program called nbody6gc based on Aarseth's series of N-body codes. We describe the algorithm in detail. We report about the density wave phenomenon in the tidal arms which has been recently explained by Kuepper et al. (2008). Standing waves develop in the tidal arms. The wave knots or clumps develop at the position, where the emerging tidal arm hits the potential wall of the effective potential and is reflected. The escaping stars move through the wave knots further into the tidal arms. We show the consistency of the positions of the wave knots with the theory in Just et al. (2009). We also demonstrate a simple method to study the properties of tidal arms. By solving many eigenvalue problems along the tidal arms, we construct numerically a 1D coordinate system whose direction is always along a principal axis of the local tensor of inertia. Along this coordinate system, physical quantities can be evaluated. The half-mass or dissolution times of our models are almost independent of the particle number which indicates that two-body relaxation is not the dominant mechanism leading to the dissolution. This may be a typical situation for many young star clusters. We propose a classification scheme which sheds light on the dissolution mechanism.

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4. Extragalactic Clusters

The Effect of Stellar Rotation on Colour-Magnitude Diagrams: On the apparent presence of multiple populations in intermediate age stellar clusters

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A significant number of intermediate age clusters (1-2 Gyr) in the Magellanic Clouds appear to have multiple stellar populations within them, derived from bi-modal or extended main sequence turn offs. If this is interpreted as an age spread, the multiple populations are separated by a few hundred Myr, which would call into question the long held notion that clusters are simple stellar populations. Here we show that stellar rotation in stars with masses between 1.2-1.7 Msun can mimic the effect of a double or multiple population, whereas in actuality only a single population exists. The two main causes of the spread near the turn-off are the effects of stellar rotation on the structure of the star and the inclination angle of the star relative to the observer. Both effects change the observed effective temperature, hence colour, and flux of the star. In order to match observations, the required rotation rates are 20-50observed rotation rates of similar mass stars in the Galaxy. We provide scaling relations which can be applied to non-rotating isochrones in order to mimic the effects of rotation. Finally, we note that rotation is unlikely to be the cause of the multiple stellar populations observed in old globular clusters, as low mass stars (< 1 Msun) are not expected to be rapid rotators.

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Gemini Spectroscopic Survey of Young Star Clusters in Merging/Interacting Galaxies. III. The Antennae

Nate Bastian([1]) Gelys Trancho([2]) Iraklis Konstantopoulos([2,3]) Bryan Miller([2])
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We present optical spectroscopy of 16 star clusters in the merging galaxies NGC 4038/39 ("The Antennae") and supplement this dataset with HST imaging. The age and metallicity of each cluster is derived through a comparison between the observed Balmer and metal line strengths with simple stellar population models. We then estimate extinctions and masses using the photometry. We find that all but three clusters have ages between ∼3-200 Myr, consistent with the expected increase in the star-formation rate due to the merger. Most of the clusters have velocities in agreement with nearby molecular and HI gas that has been previously shown to be rotating within the progenitor galaxies, hence star/cluster formation is still taking place within the galactic disks. However, three clusters have radial velocities that are inconsistent with being part of the rotating gas disks, which is surprising given their young (200-500 Myr) ages. Interestingly, we find a stellar association with the same colors (V-I) near one of these three clusters, suggesting that the cluster and association were formed concurrently and have remained spatially correlated. We find evidence for spatially distributed cluster formation throughout the duration of the merger. The impact of various assumptions about the star/cluster formation rate on the interpretation of the cluster age distribution are explored, and we do not find evidence for long term "infant mortality" as has been previously suggested. Models of galaxy mergers that include a prescription for star formation can provide an overall good fit to the observed cluster age distribution.

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Massive Clusters in the Inner Regions of NGC 1365: Cluster Formation and Gas Dynamics in Galactic Bars

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Cluster formation and gas dynamics in the central regions of barred galaxies are not well understood. This paper reviews the environment of three 10^7 $M_\odot$ clusters near the inner Lindblad resonance of the barred spiral NGC 1365. The morphology, mass, and flow of HI and CO gas in the spiral and barred regions are examined for evidence of the location and mechanism of cluster formation. The accretion rate is compared with the star formation rate to infer the lifetime of the starburst. The gas appears to move from inside corotation in the spiral region to looping filaments in the interbar region at a rate of ~ 6 $M_\odot$ yr^{-1} before impacting the bar dustlane somewhere along its length. The gas in this dustlane moves inward, growing in flux as a result of the accretion to ~ 40 $M_\odot$ yr^{-1} near the ILR. This inner rate exceeds the current nuclear star formation rate by a factor of 4, suggesting continued buildup of nuclear mass for another ~ 0.5 Gyr. The bar may be only 1-2 Gyr old. Extrapolating the bar flow back in time, we infer that the clusters formed in the bar dustlane outside the central dust ring at a position where an interbar filament currently impacts the lane. The ram pressure from this impact is comparable to the pressure in the bar dustlane, and both are comparable to the pressure in the massive clusters. Impact triggering is suggested. The isothermal assumption in numerical simulations seems inappropriate for the rarefraction parts of spiral and bar gas flows. The clusters have enough lower-mass counterparts to suggest they are part of a normal power law mass distribution. Gas trapping in the most massive clusters could explain their [NeII] emission, which is not evident from the lower-mass clusters nearby.

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5. Dynamical evolution - Simulations

The photometric evolution of dissolving star clusters: II. Realistic models. Colours and M/L ratios

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Evolutionary synthesis models are the prime method to construct models of stellar populations, and to derive physical parameters from observations. One of the assumptions for such models so far has been the time-independence of the stellar mass function. However, dynamical simulations of star clusters in tidal fields have shown the mass function to change due to the preferential removal of low-mass stars from clusters. Here we combine the results from dynamical simulations of star clusters in tidal fields with our evolutionary synthesis code GALEV to extend the models by a new dimension: the total cluster disruption time. We reanalyse the mass function evolution found in N-body simulations of star clusters in tidal fields, parametrise it as a function of age and total cluster disruption time and use this parametrisation to compute GALEV models as a function of age, metallicity and the total cluster disruption time. We study the impact of cluster dissolution on the colour (generally, they become redder) and magnitude (they become fainter) evolution of star clusters, their mass-to-light ratios (off by a factor of $\sim$2 – 4 from standard predictions), and quantify the effect on the cluster age determination from integrated photometry (in most cases, clusters appear to be older than they are, between 20 and 200%). By comparing our model results with observed M/L ratios for old compact objects in the mass range $10^{4.5}$ – 10^{8} Msun, we find a strong discrepancy for objects more massive than 10^{7} Msun (higher M/L). This could be either caused by differences in the underlying stellar mass function or be an indication for the presence of dark matter in these objects. Less massive objects are well represented by the models. The models for a range of total cluster disruption times are available online.

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Binary dynamics near a massive black hole

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We analyze the dynamical evolution of binary stars that interact with a static background of single stars in the environment of a massive black hole (MBH). All stars are considered to be single mass, Newtonian point particles. We follow the evolution of the energy E and angular momentum J of the center of mass of the binaries with respect to the MBH, as well as their internal semi-major axis a, using a Monte Carlo method.

For a system like the Galactic center, the main conclusions are the following: (1) The binary fraction can be of the order of a few percent outside 0.1 pc, but decreases quickly closer to the MBH. (2) Within $\sim$0.1 pc, binaries can only exist on eccentric orbits with apocenters much further away from the MBH. (3) Far away from the MBH, loss-cone effects are the dominant mechanism that disrupts binaries with internal velocities close to the velocity dispersion. Closer to the MBH, three-body encounters are more effective in disrupting binaries. (4) The rate at which hard binaries become tighter is usually less than the rate at which a binary diffuses to orbits that are more bound to the MBH. (5) Binaries are typically disrupted before they experience an exchange interaction; as a result, the number of exchanges is less than one would estimate from a simple "$nv\sigma$ estimate".

We give applications of our results to the formation of X-ray binaries near MBHs and to the production rates of hyper-velocity stars by intermediate mass MBHs.

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Influence of a stellar cusp on the dynamics of young stellar discs and the origin of the S-stars in the Galactic Centre

Ulf Löckmann, Holger Baumgardt, and Pavel Kroupa
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Observations of the Galactic Centre show evidence of one or two disc-like structures of very young stars orbiting the central super-massive black hole within a distance of a few 0.1 pc. A number of analyses have been carried out to investigate the dynamical behaviour and consequences of these discs, including disc thickness and eccentricity growth as well as mutual interaction and warping. However, most of these studies have neglected the influence of the stellar cusp surrounding the black hole, which is believed to be 1-2 orders of magnitude more massive than the disc(s).

By means of N-body integrations using our bhint code, we study the impact of stellar cusps of different compositions. We find that although the presence of a cusp does have an important effect on the evolution of an otherwise isolated flat disc, its influence on the evolution of disc thickness and warping is rather mild in a two-disc configuration. However, we show that the creation of highly eccentric orbits strongly depends on the graininess of the cusp (i.e. the mean and maximum stellar masses): While Chang (2009) recently found that full cycles of Kozai resonance are prevented by the presence of an analytic cusp, we show that relaxation processes play an important role in such highly dense regions and support short-term resonances. We thus find that young disc stars on initially circular orbits can achieve high eccentricities by resonant effects also in the presence of a cusp of stellar remnants, yielding a mechanism to create S-stars and hyper-velocity stars.

Furthermore, we discuss the underlying initial mass function (IMF) of the young stellar discs and find no definite evidence for a non-canonical IMF.

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For preprints, contact `uloeck@astro.uni-bonn.de`
Also available from the URL `http://arxiv.org/abs/0906.0574`
or by anonymous ftp at

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6. Miscellaneous

Episodic accretion at early stages of evolution of low mass stars and brown dwarfs: a solution for the observed luminosity spread in HR diagrams?

I. Baraffe, G. Chabrier, J. Gallardo
CRAL-ENS-Lyon, Universidad de Chile

We present evolutionary models for young low mass stars and brown dwarfs taking into account episodic phases of accretion at early stages of the evolution, a scenario supported by recent large surveys of embedded protostars. An evolution including short episodes of vigorous accretion ($\dot{M} \geq 10^{-4} M_{\odot}/yr$) followed by longer quiescent phases ($\dot{M} < 10^{-6} M_{\odot}/yr$) can explain the observed luminosity spread in HR diagrams of star forming regions at ages of a few Myr, for objects ranging from a few Jupiter masses to a few tenths of a solar mass. The gravitational contraction of these accreting objects strongly departs from the standard Hayashi track at constant Teff The best agreement with the observed luminosity scatter is obtained if most of the accretion shock energy is radiated away.The obtained luminosity spread at 1 Myr in the HR diagram is equivalent to what can be misinterpreted as a $\sim$ 10 Myr age spread for non-accreting objects. We also predict a significant spread in radius at a given Teff, as suggested by recent observations. These calculations bear important consequences on our understanding of star formation a nd early stages of evolution and on the determination of the IMF for young ($\leq$ a few Myr) clusters. Our results also show that the concept of a stellar birthline for low-mass objects has no valid support.

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Dissolution of Star Clusters in the Galaxy and its Center

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This thesis is concerned with investigations on the dissolution of star clusters in the tidal field of the Galaxy and in particular its center. At first the escape process of stars from star clusters is studied in the framework of chaos-theoretical considerations. Already in the linear tidal approximation it is possible to compute the basins of escape and the chaotic saddle for the system. After the stars have left the star cluster they form tidal arms (or tails) due to the differential rotation of the Galaxy. For star clusters on circular orbits the theoretical framework for the investigation of the properties of tidal arms is discussed. The theory is applied for a star cluster model in the Galactic center. For this purpose a new N-body program called NBODY6GC has been developed. The algorithm is described in detail and the results of N-body simulations are discussed. At certain positions, well-defined clumps develop in the tidal arms due to the epicyclic motion of the stars. The positions of the clumps are calculated with the analytical theory. Furthermore, a classification of the cluster stars according to radius and specific Jacobi energy is introduced in order to explain the dissolution times and a few results on the "paradox of youth" are formulated.

PhD thesis, University of Heidelberg (2009), Supervisor: PD Dr. Andreas Just
For further information, contact aernst@ari.uni-heidelberg.de
Also available from the URL http://www.ub.uni-heidelberg.de/archiv/9375

Star clusters in the Whirlpool Galaxy

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This thesis presents the results of observational studies of the star cluster population in the interacting spiral galaxy M51, also known as the Whirlpool galaxy. Observations taken by the Hubble Space Telescope in the optical and the near-UV are used to determine fundamental properties of the star clusters, such as their ages, masses, radii and their spatial distribution. We study how these properties are related and how they depend on different environmental conditions in the galaxy, such as galactocentric radius and the distance from the spiral arms. By comparing the properties of the young star clusters to the properties of the giant molecular clouds from which they form, we study the process of star formation indirectly. We determine the radius distribution of 1284 young star clusters, which is different compared to the radius distribution of the giant molecular clouds. This suggests that during the formation of star clusters their radii change in a non-uniform way. The majority of the youngest star clusters are found in the spiral arms and these clusters are slightly more compact compared to older star clusters in the interarm regions. We discover a peculiar, fuzzy object with a projected position close to the nucleus of M51. After considering different scenarios for this object, we conclude that this object is most likely a fuzzy star cluster in front of the disc, with an age of 1.4 Gyr. The spatial distribution of the young star clusters is analysed using two-point autocorrelation functions. From this we find that the positions of the star clusters show a hierarchy with a fractal dimension similar to that of the turbulent interstellar medium in other galaxies, suggesting that star formation is hierarchical with a universal fractal dimension. Exploiting different multi-wavelength data sets we compare the positions of current star formation sites and recently formed star clusters younger than 10 Myr. A quantitative comparison between star and cluster formation is used to study the rapid dispersion, also called infant mortality, of young star clusters. Both star and cluster formation peak in the spiral arms and in the centre of the galaxy, but also at a galactocentric radius of 2.5 and 5 kpc, which is likely caused by the presence of the 4:1 resonance and the corotation radius, respectively. We derive the star cluster formation efficiency, which is the fraction of star formation that takes place in the star clusters we observe. We correct this fraction for selection effects by use of the cluster initial mass function, which we derive from our new data. We conclude that 20% of the star formation takes place in the form of star clusters. The remaining 80% takes place in a dispersed way, suggesting that the infant mortality can be as high as 80% and occurring on timescales of less than 10 Myr.

Further comments: Thesis defended on June 16, 2009. Promotor: prof. dr. H.J.G.L.M. Lamers Co-promotor: dr. S.S. Larsen A free printed copy of this thesis can be requested by e-mail.

To appear in : PhD thesis
For preprints, contact `r.a.scheepmaker@uu.nl`
Also available from the URL
`http://igitur-archive.library.uu.nl/dissertations/2009-0615-200436/UUindex.html`
or by anonymous ftp at `ftp://`

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The Birth and Influence of Massive Stars
Prague 14 - 17 September 2009
CONSTELLATION Work Package 2 - Interim Meeting

The Birth and Influence of Massive Stars is the subject of the
Marie Curie Research Training Network CONSTELLATION (MCRTN-CT-2006-035890).
It is an important area of astrophysics joining three interconnected sub-topics:

1. The initial conditions for massive star formation;
2. The influence of the environment on massive star formation;
3. Feedback from massive stars.

Star formation scenarios based on turbulent fragmentation, protostellar feedback, or competitive accretion are explored.
A detailed picture of massive star formation in the Milky Way available through radio interferometers, ground-based optical/IR imaging systems, IR space telescopes and X-ray astronomical satellites, is compared with state-of-the-art numerical models of the massive star formation process. Analytical solutions are provided, in some cases helping to disentangle physical processes in the game. We investigate the initial conditions in the dark clouds - extremely dense, massive molecular cloud cores forming massive stars and massive star clusters. Direct measurements of the environment provide important insight into their formation mechanism. Mechanical and radiatively-driven feedback by winds and ionisation affect the surroundings of massive stars, forming expanding shells, unbinding stellar clusters and triggering secondary star formation in compressed layers.
This interim meeting of Work Package 2 of the CONSTELLATION network will review the above aspects of massive star formation and showcase the progress made over the past more than two years of cooperation.
Due to the capacity of the venue, we are limited to 50 participants.
The places will be allocated on a first-come, first-served basis.
Further information:

`http://galaxy.ig.cas.cz/~richard/0909-prague`.

Ian Bonnell Jan Palouš Ant Whitworth

First Announcement for the AMUSE kickoff meeting and workshop Leiden, October 5-7

1.) General information

You are cordially invited for a 3-day meeting and workshop to kick-start the development of the astrophysical multipurpose software environment (AMUSE). Building on the success and experiences of MUSE, this package aims to integrate numerical astrophysical codes for multi-scale and multi-physics problems in stellar dynamics and galactic astrophysics. During the workshop key aspects of the preliminary AMUSE design and first release will be presented in a very much hands-on meeting. There will be ample time to learn about the capabilities of AMUSE and the steps needed to run simulations, integrate new codes or get them integrated into AMUSE. The input from participants in the workshop will decide upon the outlines of further development of the interface and technical design. Thus to ensure maximum involvement of the community we want to bring together researchers and developers of astrophysical codes with the MUSE designers at this workshop meeting.

2.) Date and venue

The workshop will be hosted on October 5th to 7th at the Leiden Observatory:

Leiden Observatory
University of Leiden
Niels Bohrweg 2
NL-2333 CA Leiden
The Netherlands

3.) Organization & Contact

the organizing committee consists of:
Gijs Nelemans
Marco Spaans
Simon Portegies Zwart
Arjen van Elteren
Inti Pelupessy

to be contacted at: `amuse_workshop_2009'at'strw.leidenuniv.nl`

4.) Registration

For participation in this this workshop no fee will be due. Registration can be done by sending an email to `amuse_workshop_2009'at'strw.leidenuniv.nl` providing personal information (name, position & affiliation). The registration deadline is September 1st. Early registration is appreciated.

5.) Program

The program will consist of presentations by the core development team on the current status and design of AMUSE. Furthermore a small number of invited talks will be held on scientific topics connected to AMUSE. About half of the program will consist of hands-on workshop sessions where small groups will work on AMUSE code.

More information about the workshop can be found at the following website:

`http://www.strw.leidenuniv.nl/amuse_workshop_2009`

Several PhD positions available in Simulating Galaxy Mergers

With Simon Portegies Zwart
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Tel. +31 (0)71 527 8429

We are looking for excellent graduate students to work in a research project on colliding galaxies with supermassive black holes. The candidate should start by January 2010, the position is for 4 years and will culminate in a PhD degree.

The objective is to study the merging of super-massive black holes in the central regions of galaxies throughout the process in which two galaxies merge. Our theoretical understanding of the circumstances under which super-massive black holes coalesce is poorly developed, in particular if the host galaxies contain little gas. The research will be conducted using hierarchical and hybrid simulation environments in with Barnes-Hut Tree-code and direct N-body integration methods will be combined in order to solve the equations of motion of the galaxies and their central black holes. The calculations will be run on a cluster graphical processing units and GRAPEs. The available positions require frequent interactions within the research team and with international collaborators. Successful candidates should have an Master degree in computational science, astrophysics or a related field. Experience in software development and programming in Python/C/C++/MPI/CUDA are an advantage, as is an interest and experience in galaxy mergers, the dynamics around super-massive black holes and gravitational dynamics in general.

Candidates are requested to submit in confidence a curriculum vitae and cover letter to J. Droste (mention "VICI" in the Subject heading). The names and contact information of 3 persons should be provided for reference. For full consideration, applications must be received by 1 November 2009.

The appointment will be for 38 hours a week for a period of four years and leads to a PhD. The gross monthly salary will be in accordance with the University regulations and ranges from 2042Euro (first year) to 2612Euro (fourth year) based on a full-time appointment, plus an additional 8% holiday and 8% end-of-year bonus.