$\mathcal{SCYON}$

The Star Clusters Young & Old Newsletter

edited by Holger Baumgardt, Ernst Paunzen and Pavel Kroupa

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SCYON Issue No. 36 *17 December 2007*

EDITORIAL

This is the 36th issue of the SCYON newsletter. It contains 31 abstracts from refereed publications and conference proceedings and two announcements for conferences in Strasbourg and Garching.

We wish everybody a merry holiday season and a happy new year 2008 and 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.

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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

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1. Star Forming Regions

Variations in Stellar Clustering with Environment: Dispersed Star Formation and the Origin of Faint Fuzzies

Bruce G. Elmegreen
IBM Watson Research Center

The observed increase in star formation efficiency with average cloud density, from several percent in whole giant molecular clouds to 30 percent or more in cluster-forming cores, can be understood as the result of hierarchical cloud structure if there is a characteristic density as which individual stars become well defined. Also in this case, the efficiency of star formation increases with the dispersion of the density probability distribution function (pdf). Models with log-normal pdf's illustrate these effects. The difference between star formation in bound clusters and star formation in loose groupings is attributed to a difference in cloud pressure, with higher pressures forming more tightly bound clusters. This correlation accounts for the observed increase in clustering fraction with star formation rate and with the observation of Scaled OB Associations in low pressure environments. "Faint fuzzie" star clusters, which are bound but have low densities, can form in regions with high Mach numbers and low background tidal forces. The proposal by Burkert, Brodie and Larsen (2005) that faint fuzzies form at large radii in galactic collisional rings, satisfies these constraints.

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2. Galactic Open Clusters

The Distances to Open Clusters from Main-Sequence Fitting. IV. Galactic Cepheids, the LMC, and the Local Distance Scale

Deokkeun An, Donald M. Terndrup, Marc H. Pinsonneault
The Ohio State University

We derive the basic properties of seven Galactic open clusters containing Cepheids and construct their period-luminosity (P-L) relations. For our cluster main-sequence fitting we extend previous Hyades-based empirical color-temperature corrections to hotter stars using the Pleiades as a template. We use BVI_CJHK_s data to test the reddening law, and include metallicity effects to perform a more comprehensive study for our clusters than prior efforts. The ratio of total to selective extinction R_V that we derive is consistent with expectations. Assuming the LMC P-L slopes, we find $< M_V >$ = -3.93 +/- 0.07 (statistical) +/- 0.14 (systematic) for 10-day period Cepheids, which is generally fainter than those in previous studies. Our results are consistent with recent HST and Hipparcos parallax studies when using the Wesenheit magnitudes W(VI). Uncertainties in reddening and metallicity are the major remaining sources of error in the V-band P-L relation, but a higher precision could be obtained with deeper optical and near-infrared cluster photometry. We derive distances to NGC4258, the LMC, and M33 of $(m - M)_0$ = 29.28 +/- 0.10, 18.34 +/- 0.06, and 24.55 +/- 0.28, respectively, with an additional systematic error of 0.16 mag in the P-L relations. The distance to NGC4258 is in good agreement with the geometric distance derived from water masers [$\Delta(m - M)_0$ = 0.01 +/- 0.24]; our value for M33 is less consistent with the distance from an eclipsing binary [$\Delta(m - M)_0$ = 0.37 +/- 0.34]; our LMC distance is moderately shorter than the adopted distance in the HST Key Project, which formally implies an increase in the Hubble constant of 7% +/- 8%.

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Galactic Rotation Parameters from Data on Open Star Clusters

Bobylev, V.V.; Bajkova A.T.; Lebedeva S.V.
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Currently available data on the field of velocities Vr,Vl,Vb for open star clusters are used to perform a kinematic analysis of various samples that differ by heliocentric distance, age, and membership in individual structures (the Orion, Carina-Sagittarius, and Perseus arms). Based on 375 clusters located within 5 kpc of the Sun with ages up to 1 Gyr, we have determined the Galactic rotation parameters Wo =-26.0+-0.3 km/s/kpc, W'o = 4.18+-0.17 km/s/kpc^2, W"o=-0.45+-0.06 km/s/kpc^3, the system contraction parameter K = -2.4+-0.1 km/s/kpc, and the parameters of the kinematic center Ro =7.4+-0.3 kpc and lo = 0+-1 degrees. The Galactocentric distance Ro in the model used has been found to depend significantly on the sample age. Thus, for example, it is 9.5+-0.7 kpc and 5.6+-0.3 kpc for the samples of young (< 50 Myr) and old (> 50 Myr) clusters, respectively. Our study of the kinematics of young open star clusters in various spiral arms has shown that the kinematic parameters are similar to the parameters obtained from the entire sample for the Carina-Sagittarius and Perseus arms and differ significantly from them for the Orion arm. The contraction effect is shown to be typical of star clusters with various ages. It is most pronounced for clusters with a mean age of 100 Myr, with the contraction velocity being Kr = -4.3+-1.0 km/s.

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Tidal radii and masses of open clusters

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Abstract

In a previous paper we obtained King's parameters for 236 of 650 Galactic open clusters identified in the ASCC. Estimating tidal radii by use of observable parameters available for all clusters. Bias-free results are required. We use methods of stellar statistics and develop a semi-empirical model of open clusters. We check two effects impacting the determination of tidal radii from a fitting of King's profiles to the observed density distribution, i.e., ellipticity of open clusters and a bias depending on distances. Though a typical cluster has an elliptical form, the effect is rather weak to produce a prominent bias in the resulting tidal radii. In contrast, a distance dependent bias is not negligible and can cause a systematic underestimation of tidal radii computed with ASCC data by a factor of two for the most distant clusters of our sample. This finding is used to correct the original results for 236 clusters and to extend the system of tidal radii and masses to all 650 clusters. We found that the semi-major axis of the projected distribution of cluster members on the sky is a parameter suited to estimate tidal radii of open clusters of our sample. No systematic differences are found between measured and calibrated tidal radii. From the comparison with mass estimates based on star counts and on the assumption of the Salpeter IMF, empirical evidence is obtained for an evolution of cluster mass functions starting in young clusters. The set of homogeneous parameters available for all clusters of our sample is extended by tidal radius and mass. Within 850 pc where our sample is complete, the distributions of tidal radii and masses peak at $r_t \approx 6$ pc and $\log M_c/m_\odot \approx 2.5$, espectively. In young open clusters, the mass distributions show differences to the Salpeter IMF, and this discrepancy increases with cluster age.

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Stars and brown dwarfs in the sigma Orionis cluster: the Mayrit catalogue

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The young sigma Orionis cluster is an indispensable basis for understanding the formation and evolution of stars, brown dwarfs, and planetary-mass objects. Our knowledge of its stellar population is, however, incomplete. I present the Mayrit catalogue, which comprises most of the stars and high-mass brown dwarfs in the cluster. The basis of this work is an optical-near infrared correlation between the 2MASS and DENIS catalogues in a circular area of radius 30 arcmin centred on the OB-type binary sigma Ori AB. The analysis is supported by a bibliographic search of confirmed cluster members with features of youth and by additional X-ray, mid-infrared, and astrometric data. I list 241 sigma Orionis stars and brown dwarfs with known features of youth, 97 candidate cluster members (40 are new), and 115 back- and foreground sources in the survey area. The 338 cluster members and member candidates constitute the Mayrit catalogue. This catalogue is a suitable input for studying the spatial ditribution, multiplicity, properties and frequency of discs, and the complete mass function of sigma Orionis.

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Old open clusters in the outer Galactic disk

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The outer parts of the Milky Way disk are believed to be one of the main are nas where the accretion of external material in the form of dwarf galaxies and subsequent formation of streams is taking place. The Monoceros stream and the Canis Major and Argo over-densities are notorious examples. Understanding whether what we detect is the signature of accretion or, more conservatively, simply the intrinsic nature of the disk, represents one of the major goals of modern Galactic astronomy. We try to shed more light on the properties of the outer disk by exploring the properties of distant anti-center old open clusters. We want to verify whether distant clusters follow the chemical and dynamical behavior of the solar vicinity disk, or whether their properties can be better explained in terms of an extra-galactic population. VLT high resolution spectra have been acquired for five distant open clusters: Ruprecht 4, Ruprecht 7, Berkeley 25, Berkeley 73 and Berkeley 75. We derive accurate radial velocities to distinguish field interlopers and cluster members. For the latter we perform a detailed abundance analysis and derive the iron abundance [Fe/H] and the abundance ratios of several α elements. Our analysis confirms previous indications that the radial abundance gradient in the outer Galactic disk does not follow the expectations extrapolated from the solar vicinity, but exhibits a shallower slope. By combining the metallicity of the five program clusters with eight more clusters for which high resolution spectroscopy is available, we find that the mean metallicity in the outer disk between 12 and 21 kpc from the Galactic center is [Fe/H] ≈ -0.35, with only marginal indications for a radial variation. In addition, all the program clusters exhibit solar scaled or slightly enhanced α elements, similar to open clusters in the solar vicinity and thin disk stars. We investigate whether this outer disk cluster sample might belong to an extra-galactic population, like the Monoceros ring. However, close scrutiny of their properties - location, kinematics and chemistry - does not convincingly favor this hypothe sis. On the contrary, they appear more likely genuine Galactic disk clusters. We finally stress the importance to obtain proper motion measurements for these clusters to constrain their orbits.

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The cool supergiant population of the massive young star cluster RSGC1

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We present new high-resolution near-IR spectroscopy and OH maser observations to investigate the population of cool luminous stars of the young massive Galactic cluster RSGC1. Using the 2.293 micron CO-bandhead feature, we make high-precision radial velocity measurements of 16 of the 17 candidate Red Supergiants (RSGs) identified by Figer et al. We show that F16 and F17 are foreground stars, while we confirm that the rest are indeed physically-associated RSGs. We determine that Star F15, also associated with the cluster, is a Yellow Hypergiant based on its luminosity and spectroscopic similarity to ρ Cas. Using the cluster's radial velocity, we have derived the kinematic distance to the cluster and revisited the stars' temperatures and luminosities. We find a larger spread of luminosities than in the discovery paper, consistent with a cluster age 30% older than previously thought (12±2Myr), and a total initial mass of $(3 \pm 1) \times 10^4$ $M_\odot$. The spatial coincidence of the OH maser with F13, combined with similar radial velocities, is compelling evidence that the two are related. Combining our results with recent SiO and H_2O maser observations, we find that those stars with maser emission are the most luminous in the cluster. From this we suggest that the maser-active phase is associated with the end of the RSG stage, when the luminosity-mass ratios are at their highest.

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Late stages of the evolution of A-type stars on the main sequence: comparison between observed chemical abundances and diffusion models for 8 Am stars of the Praesepe cluster.

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We aim to provide observational constraints on diffusion models that predict peculiar chemical abundances in the atmospheres of Am stars. We also intend to check if chemical peculiarities and slow rotation can be explained by the presence of a weak magnetic field. We have obtained high resolution, high signal-to-noise ratio spectra of eight previously-classified Am stars, two normal A-type stars and one Blue Straggler, considered to be members of the Praesepe cluster. For all of these stars we have determined fundamental parameters and photospheric abundances for a large number of chemical elements, with a higher precision than was ever obtained before for this cluster. For seven of these stars we also obtained spectra in circular polarization and applied the LSD technique to constrain the longitudinal magnetic field. No magnetic field was detected in any of the analysed stars. HD 73666, a Blue Straggler previously considered as an Ap(Si) star, turns out to have the abundances of a normal A-type star. Am classification is not confirmed for HD 72942. For HD 73709 we have also calculated synthetic Delta a photometry that is in good agreement with the observations. There is a generally good agreement between abundance predictions of diffusion models and values that we have obtained for the remaining Am stars. However, the observed Na and S abundances deviate from the predictions by 0.6 dex and <= 0.25 dex respectively. Li appears to be overabundant in three stars of our sample.

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Stellar contents and star formation in the young open cluster Stock 8

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We present $UBVI_c$ CCD photometry of the young open cluster Stock 8 with the aim of studying its basic properties such as the amount of interstellar extinction, distance, age, stellar contents and initial mass function (IMF). We also studied the star formation scenario in this region. From optical data, the radius of the cluster is found to be $\sim 6'$ (~ 3.6 pc) and the reddening within the cluster region varies from $E(B-V) = 0.40$ to 0.60 mag. The cluster is located at a distance of 2.05 ± 0.10 kpc. Using Hα slitless spectroscopy and 2MASS NIR data we identified Hα emission and NIR excess young stellar objects (YSOs), respectively. From their locations in the colour-magnitude diagrams, majority of them seem to have ages between 1 to 5 Myr. The spread in their ages indicate a possible non-coeval star formation in the cluster. Massive stars in the cluster region reveal an average age of ≤ 2 Myr. In the cluster region ($r \leq 6'$) the slope of the mass function (MF), Γ, in the mass range $\sim 1.0 \leq M/M_{\odot} < 13.4$ can be represented by a power law having a slope of -1.38 ± 0.12, which agrees well with Salpeter value (-1.35). In the mass range $0.3 \leq M/M_{\odot} < 1.0$, the MF is also found to follow a power law with a shallower slope of $\Gamma = -0.58 \pm 0.23$ indicating a break in the slope of the IMF at $\sim 1 M_{\odot}$. The slope of the K-band luminosity function for the cluster ($r \leq 6'$) is found to be 0.31 ± 0.02, which is smaller than the average value (~ 0.4) obtained for embedded star clusters.

A significant number of YSOs are distributed along a Nebulous Stream towards the east side of the cluster. A small cluster is embedded in the Nebulous Stream. The YSOs lying in the Nebulous Stream and in the embedded cluster are found to be younger than the stars in the cluster Stock 8. The radio continuum, MSX, IRAS mid- and far-infrared maps and the ratio of $[SII]$/Hα intensities indicate that the eastern region of Stock 8 is ionization bounded whereas the western region is density bounded. The morphology seems to indicate that the ionization/ shock front caused by the ionizing sources located in the Stock 8 region and westwards of Stock 8 has not reached the Nebulous Stream. It appears that star formation activity in the Nebulous Stream and embedded cluster may be independent from that of Stock 8.

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In Search of Possible Associations between Planetary Nebulae and Open Clusters

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We consider the possibility of cluster membership for 13 planetary nebulae that are located in close proximity to open clusters lying in their lines of sight. The short lifetimes and low sample size of intermediate-mass planetary nebulae with respect to nearby open clusters conspire to reduce the probability of observing a true association. Not surprisingly, line of sight coincidences almost certainly exist for 7 of the 13 cases considered. Additional studies are advocated, however, for 6 planetary nebula/open cluster coincidences in which a physical association is not excluded by the available evidence, namely M 1-80/Berkeley 57, NGC 2438/NGC 2437, NGC 2452/NGC 2453, VBRC 2 & NGC 2899/IC 2488, and HeFa 1/NGC 6067. A number of additional potential associations between planetary nebulae and open clusters is tabulated for reference purposes. It is noteworthy that the strongest cases involve planetary nebulae lying in cluster coronae, a feature also found for short-period cluster Cepheids, which are themselves potential progenitors of planetary nebulae.

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Detection of the lithium depletion boundary in the young open cluster IC 4665

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The so-called lithium depletion boundary (LDB) provides a secure and independent tool for deriving the ages of young open clusters. In this context, our goal is to determine membership for a sample of 147 photometrically selected candidates of the young open cluster IC 4665 and to use confirmed members to establish an age based on the LDB. Employing the FLAMES multi-object spectrograph on VLT/UT2, we have obtained intermediate-resolution spectra of the cluster candidates. The spectra were used to measure radial velocities and to infer the presence of the Li 670.8 nm doublet and Hα emission. We have identified 39 bona fide cluster members based on radial velocity, Hα emission, and Li absorption. The mean radial velocity of IC 4665 is found to be -15.95 ± 1.13 km/s. Confirmed cluster members display a sharp transition in magnitude between stars with and without lithium, both in the I_m and in the K_s diagrams. From this boundary, we deduce a cluster age of $27.7^{+4.2}_{-3.5} \pm 1.1 \pm 2$ Myr. IC 4665 is the fifth cluster for which an LDB age has been determined, and it is the youngest cluster among these five. Thus, the LDB is established from relatively bright stars still in the contracting pre-main sequence phase. The mass of the boundary is $M_* = 0.24 \pm 0.04\ M_\odot$. The LDB age agrees well with the ages derived from isochrone fitting of both low and high mass, turn–off stars, a result similar to what is found in the slightly older NGC 2547.

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3. Galactic Center Clusters

The most massive stars in the Arches cluster

F. Martins ([1]), D.J. Hillier ([2]), T. Paumard ([3]), F. Eisenhauer ([1]), T. Ott ([1]), R. Genzel ([1,4])

[1]- MPE Garching [2]- University of Pittsburgh [3]- LESIA Paris-Meudon [4]- University of Berkeley

We study a sample composed of 28 of the brightest stars in the Arches cluster. We analyze K-band spectra obtained with the integral field spectrograph SINFONI on the VLT. Atmosphere models computed with the code CMFGEN are used to derive the effective temperatures, luminosities, stellar abundances, mass loss rates and wind terminal velocities. We find that the stars in our sample are either H-rich WN7-9 stars (WN7-9h) or O supergiants, two being classified as OIf+. All stars are 2-4 Myr old. There is marginal evidence for a younger age among the most massive stars. The WN7-9h stars reach luminosities as large as 2 x 10^6 Lsun, consistent with initial masses of $\sim$ 120 Msun. They are still quite H-rich, but show both N enhancement and C depletion. They are thus identified as core H-burning objects showing products of the CNO equilibrium at their surface. Their progenitors are most likely supergiants of spectral types earlier than O4-6 and initial masses $>$ 60 Msun. Their winds follow a well defined modified wind momentum - luminosity relation (WLR): this is a strong indication that they are radiatively driven. Stellar abundances tend to favor a slightly super solar metallicity, at least for the lightest metals. We note however that the evolutionary models seem to under-predict the degree of N enrichment.

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4. Galactic Globular Clusters

Are Globular Clusters the Remnant Nuclei of Progenitor Disk Galaxies?

Torsten Boeker
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The globular cluster system of a typical spheroidal galaxy makes up about 0.25% of the total galaxy mass (McLaughlin 1999). This is roughly the same mass fraction as contained in the nuclear star clus- ter (or stellar nucleus) present in most nearby low-mass galaxies. Motivated by this "coincidence", this Letter discusses a scenario in which globular clusters of present-day galaxies are the surviving nuclei of the dwarf galaxies that - according to the hierarchical merging paradigm of galaxy forma- tion - constitute the "building blocks" of present-day massive galaxies. This scenario, which was first suggested by Freeman (1993), has become more attractive recently in the light of studies that demonstrate a complex star formation history in a number of massive globular clusters.

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FSR0190 - Another old distant galactic cluster

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([1]) University of Kent ([2]) Thueringer Landessternwarte Tautenburg ([3]) Joint Astronomy Center

We are conducting a large program to classify newly discovered Milky Way star cluster candidates from Froebrich et al. (2007). Here we present NIR follow-up observations of FSR0190 (RA=20h05m31.3s, DEC=33deg34'09", J2000). The cluster is situated close to the Galactic Plane (l=70.7302deg, b=+0.9498deg). It shows a circular shape, a relatively large number of core helium burning stars – which clearly distinguishes the cluster from the rich field – but no centrally condensed star density profile. We derive an age of more than 7Gyr, a Galactocentric distance of 10.5kpc, a distance of 10kpc from the Sun, and an extinction of $A_K = 0.8$ mag. The estimated mass is at least of the order of $10^5 M_\odot$, and the absolute brightness is $M_V <= -4.7$ mag; both are rather typical properties for Palomar-type globular clusters.

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Dust, pulsation, chromospheres and their role in driving mass loss from red giants in Galactic globular clusters

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Context: Mass loss from red giants in old globular clusters affects the horizontal branch (HB) morphology and post-HB stellar evolution including the production of ultraviolet-bright stars, dredge up of nucleosynthesis products and replenishment of the intra-cluster medium. Studies of mass loss in globular clusters also allows one to investigate the metallicity dependence of the mass loss from cool, low-mass stars down to very low metallicities. Aims: We present an analysis of new VLT/UVES spectra of 47 red giants in the Galactic globular clusters 47 Tuc (NGC 104), NGC 362, omega Cen (NGC 5139), NGC 6388, M54 (NGC 6715) and M15 (NGC 7078). The spectra cover the wavelength region 6100-9900A at a resolving power of R = 110,000. Some of these stars are known to exhibit mid-infrared excess emission indicative of circumstellar dust. Our aim is to detect signatures of mass loss, identify the mechanism(s) responsible for such outflows, and measure the mass-loss rates. Methods: We determine for each star its effective temperature, luminosity, radius and escape velocity. We analyse the H-alpha and near-infrared calcium triplet lines for evidence of outflows, pulsation and chromospheric activity, and present a simple model for estimating mass-loss rates from the H-alpha line profile. We compare our results with a variety of other, independent methods. Results: We argue that a chromosphere persists in Galactic globular cluster giants and controls the mass-loss rate to late-K/early-M spectral types, where pulsation becomes strong enough to drive shock waves at luminosities above the RGB tip. This transition may be metallicity-dependent. We find mass-loss rates of $\sim 10^{-7}$ to 10^{-5} solar masses per year, largely independent of metallicity.

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5. Extragalactic Clusters

A peculiar object in M51: fuzzy star cluster or a background galaxy?

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Aims: We study a peculiar object with a projected position close to the nucleus of M51. It is unusually large for a star cluster in M51 and we therefore investigate the three most likely options to explain this object: (a) a background galaxy, (b) a cluster in the disk of M51 and (c) a cluster in M51, but in front of the disk. Methods: We use broad-band images of the Advanced Camera for Surveys and the Near Infrared Camera and Multi-Object Spectrometer, both on board the *Hubble Space Telescope*, to study the properties of this object. Assuming the object is a star cluster, we fit the metallicity, age, mass and extinction using simple stellar population models. Assuming the object is a background galaxy, we estimate the extinction from the colour of the background around the object. We study the structural parameters of the object by fitting the spatial profile with analytical models. Results: We find de-reddened colours of the object which are bluer than expected for a typical elliptical galaxy, and the central surface brightness is brighter than the typical surface brightness of a disc galaxy. It is therefore not likely that the object is a background galaxy. Assuming the object is a star cluster in the disc of M51, we estimate an age and mass of $0.7^{+0.1}_{-0.1}$ Gyr and $2.2^{+0.3}_{-0.3} \times 10^5$ $M_\odot$, respectively (with the extinction fixed to $E(B-V) = 0.2$). Considering the large size of the object, we argue that in this scenario we observe the cluster just prior to final dissolution. If we fit for the extinction as a free parameter, a younger age is allowed and the object is not close to final dissolution. Alternatively, the object could be a star cluster in M51, but in front of the disc, with an age of $1.4^{+0.5}_{-0.2}$ Gyr, mass $M = 1.7^{+0.8}_{-0.3} \times 10^5$ $M_\odot$. Its effective radius is between ∼12–25 pc. This makes the object a "fuzzy star cluster", raising the issue of how an object of this age would end up outside the disc.

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The Connection between Globular Cluster Systems and their Host Galaxy and Environment: A Case Study of the Isolated Elliptical NGC 821

Lee R. Spitler[1], Duncan A. Forbes[1], Jay Strader[2], Jean P. Brodie[2] and Jay S. Gallagher III[3]

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In an effort to probe the globular cluster (GC) system of an isolated elliptical galaxy, a comprehensive analysis of the NGC 821 GC system was performed. New imaging from the WIYN Mini-Mosaic imager, supplemented with HST WFPC2 images reveals a GC system similar to those found in counterpart ellipticals located in high density environments. To put these results into the context of galaxy formation, a robustly-determined census of GC systems is presented and analysed for galaxies spanning a wide range of masses ($>M_*$), morphologies and environments.

Results from this meta-study: (1) confirm previous findings that the number of GCs normalized by host galaxy *stellar mass* increases with host stellar mass. Spiral galaxies in the sample show smaller relative GC numbers than those of massive ellipticals, suggesting the GC systems of massive ellipticals were not formed from major spiral-spiral mergers; (2) indicate that GC system numbers per unit galaxy *baryon mass* increases with host baryon mass and that *GC formation efficiency may not be universal* as previously thought; (3) suggest previously reported trends with environment may be incorrect due to sample bias or the use of galaxy stellar masses to normalize GC numbers. Thus claims for environmentally dependent GC formation efficiencies should be revisited; (4) in combination with weak lensing halo mass estimates, suggest that GCs formed in direct proportion to the halo mass; (5) are consistent with theoretical predictions whereby the local epoch of reionization did not vary significantly with environment or host galaxy type.

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6. Dynamical evolution - Simulations

Tracing Intermediate-Mass Black Holes in the Galactic Centre

Ulf Löckmann and Holger Baumgardt
AIfA, University of Bonn

We have developed a new method for post-Newtonian, high-precision integration of stellar systems containing a super-massive black hole (SMBH), splitting the forces on a particle between a dominant central force and perturbations. We used this method to perform fully collisional N-body simulations of inspiralling intermediate-mass black holes (IMBHs) in the centre of the Milky Way. We considered stellar cusps of different power-law indices and analysed the effects of IMBHs of different masses, all starting from circular orbits at an initial distance of 0.1 pc. Our simulations show how IMBHs deplete the central cusp of stars, leaving behind a flatter cusp with slope consistent with what has recently been observed. If an additional IMBH spirals into such a flat cusp, it can take 50 Myr or longer to merge with the central SMBH, thus allowing for direct observation in the near future. The final merger of the two black holes involves gravitational wave radiation which may be observable with planned gravitational wave detectors. Furthermore, our simulations reveal detailed properties of the hyper-velocity stars (HVSs) created, and how generations of HVSs can be used to trace IMBHs in the Galactic centre. We find that significant rotation of HVSs (which would be evidence for an IMBH) can only be expected among very fast stars ($v > 1000$ km/s). Also, the probability of creating a hyper-velocity binary star is found to be very small.

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The influence of residual gas expulsion on the evolution of the Galactic globular cluster system and the origin of the Population II halo

H. Baumgardt, P. Kroupa, G. Parmentier
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We present new results on the evolution of the mass function of the globular cluster system of the Milky Way,taking the effect of residual gas expulsion into account. We assume that gas embedded star clusters start with a power-law mass function with slope $\beta = 2$, similar to what is observed for the Galactic open clusters and young, massive star clusters in interacting galaxies. The dissolution of the clusters is then studied under the combined influence of residual gas expulsion driven by energy feedback from massive stars, stellar mass-loss, two-body relaxation and an external tidal field. The influence of residual gas expulsion is studied by applying results from a large grid of N-body simulations computed by Baumgardt & Kroupa (2007).

In our model, star clusters with masses less than $10^5 M_\odot$ lose their residual gas on timescales much shorter than their crossing time and residual gas expulsion is the main dissolution mechanism for star clusters, destroying about 95% of all clusters within a few 10s of Myr. We find that in this case the final mass function of globular clusters is established mainly by the gas expulsion and therefore nearly independent of the strength of the external tidal field, and that a power-law mass function for the gas embedded star clusters is turned into a present-day log-normal one, verifying the theory proposed by Kroupa & Boily (2002). Our model provides a natural explanation for the observed (near-)universality of the peak of the globular cluster mass function within a galaxy and among different galaxies. Our simulations also show that globular clusters must have started a factor of a few more concentrated than as we see them today.

Another consequence of residual gas expulsion and the associated strong infant mortality of star clusters is that the Galactic halo stars come from dissolved star clusters. Since field halo stars would come mainly from low-mass, short-lived clusters, our model would provide an explanation for the observed abundance variations of light elements among globular cluster stars and the absence of such variations among the halo field stars. Furthermore, our modelling suggests a natural tendency of $> 10^7 M_\odot$ gas clouds to retain their residual gas despite multiple supernova events, possibly explaining the complex stellar populations observed in the most massive globular clusters.

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Escape from the vicinity of fractal basin boundaries of a star cluster

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Astronomisches Rechen-Institut am Zentrum für Astronomie der Universität Heidelberg

The dissolution process of star clusters is rather intricate for theory. We investigate it in the context of chaotic dynamics. We use the simple Plummer model for the gravitational field of a star cluster and treat the tidal field of the Galaxy within the tidal approximation. That is, a linear approximation of tidal forces from the Galaxy based on epicyclic theory in a rotating reference frame. The Poincaré surfaces of section reveal the effect of a Coriolis asymmetry. The system is non-hyperbolic which has important consequences for the dynamics. We calculated the basins of escape with respect to the Lagrangian points L_1 and L_2. The longest escape times have been measured for initial conditions in the vicinity of the fractal basin boundaries. Furthermore, we computed the chaotic saddle for the system and its stable and unstable manifolds. The chaotic saddle is a fractal structure in phase space which has the form of a Cantor set and introduces chaos into the system.

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The Cold Dark Matter Halos of Local Group Dwarf Spheroidals

Jorge Penarrubia, Alan W. McConnachie, Julio F. Navarro
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We examine the dynamics of stellar systems embedded within cold dark matter (CDM) halos in order to assess observational constraints on the dark matter content of Local Group dwarf spheroidals (dSphs). Approximating the stellar and dark components by King and NFW models, respectively, we identify the parameters of dark halos consistent with the kinematics and spatial distribution of stars in dSphs as well as with cosmological N-body simulations. Our analysis shows, in agreement with previous work, that the total mass within the luminous radius is reasonably well constrained and approximately independent of the luminosity of the dwarf, highlighting the poor correspondence between luminosity and halo mass at the extremely faint end of the luminosity function. This result implies that the average density of dark matter is substantially higher in physically small systems such as Draco and Sculptor than in larger systems such as Fornax. Because massive CDM halos are denser than low mass ones at all radii, these results imply that Draco formed in a halo 5 times more massive than Fornax's despite being roughly 70 times fainter. Stellar velocity dispersion profiles ($\sigma_p(R)$) provide further constraints; in systems where data exist, $\sigma_p(R)$ remains flat almost to the nominal "tidal" radius, implying that stars are deeply embedded within their cold dark matter halos and are quite resilient to tidal disruption. We estimate that halos would need to lose more than 90% of their original mass before tides begin affecting the kinematics of stars, but even then the peak circular velocity of the dark halo, $V_{\rm max}$, is barely affected. We estimate that $V_{\rm max}$ is about 3 times higher than the central velocity dispersion of the stars, a result in agreement with previous estimates and that alleviates significantly the CDM "substructure crisis". We use these results to interpret the structural differences between the M31 and Milky Way (MW) dSph population and, in particular, the observation that M31 dwarfs are physically more extended by approximately a factor two than MW dwarfs of similar luminosity. Our modeling indicates that this difference in size should be reflected in their kinematics, and predicts that M31 dwarfs should have velocity dispersions up to a factor of ~ 2 higher than their MW counterparts. This is an eminently falsifiable prediction of CDM-motivated models of dSphs that may be verified with present observational capabilities.

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The Tidal Evolution of Local Group Dwarf Spheroidals

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Department of Physics and Astronomy, University of Victoria, 3800 Finnerty Rd., Victoria, BC, V8P 5C2, Canada

We use N-body simulations to study the evolution of dwarf spheroidal galaxies (dSphs) driven by galactic tides. We adopt a cosmologically-motivated model where dSphs are dark matter-dominated systems on eccentric orbits whose stellar component may be approximated by a King model embedded within an NFW halo. We find that these NFW-embedded King models are extraordinarily resilient to tides; the density profile of the stellar component still resembles a King model even after losing more than 99% of the stars. As tides strip the galaxy, the stellar luminosity, L, velocity dispersion, σ_0, central surface brightness, Σ_0, and core radius, R_c, decrease monotonically. Remarkably, we find that the evolution of these parameters is solely controlled by the total amount of mass lost from within the luminous radius. Of all parameters, the core radius is the least affected: after losing 99% of the stars, R_c decreases by just a factor of ~ 2, implying that even in the event of extreme mass loss the core radius is a robust measure of the original size of the system. Contrary to naive expectations, tides tend to make dSphs *more dark-matter dominated*. This is because the tightly bound central dark matter "cusp" is more resilient to disruption than the comparatively more loosely bound "cored" King profile. We examine whether tidal effects may help to explain the extremely large mass-to-light ratios of some of the newly-discovered ultra-faint Milky Way dwarfs as tidal remnants of once brighter systems. Although dSph tidal evolutionary tracks parallel the observed scaling relations in the luminosity-radius plane, they predict too steep a change in velocity dispersion compared with the observational estimates hitherto reported in the literature. The ultra-faint dwarfs are thus unlikely to be the tidal remnants of systems like Fornax, Draco, or Sagittarius. Despite spanning four decades in luminosity, dSphs appear to inhabit halos of comparable peak circular velocity, lending support to scenarios that envision dwarf spheroidals as able to form only in halos above a certain mass threshold.

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7. Miscellaneous

The effect of binaries on the dynamical mass determination of star clusters

M.B.N. Kouwenhoven & R. de Grijs
University of Sheffield (UK)

The total mass of distant star clusters is often derived from the virial theorem, using line-of-sight velocity dispersion measurements and half-light radii. Although most stars form in binary systems, this is mostly ignored when interpreting the observations. The components of binary stars exhibit orbital motion, which may increase the measured velocity dispersion, and may therefore result in a dynamical mass overestimation. In this paper we quantify the effect of neglecting the binary population on the derivation of the dynamical mass of a star cluster. We simulate star clusters numerically, and study the dependence of the derived dynamical mass on the properties of the binary population. We find that the presence of binaries plays a crucial role for very sparse clusters with a stellar density comparable to that of the field star population ($\sim$0.1 stars/pc^3), as the velocity dispersion is fully dominated by the binary orbital motion. For such clusters, the dynamical mass may overestimate the true mass by up to an order of magnitude. For very dense clusters ($> 10^7$ stars/pc^3), binaries do not affect the dynamical mass estimation significantly. For clusters of intermediate density ($0.1 - 10^7$ stars/pc^3), the dynamical mass can be overestimated by 10-100%, depending on the properties of the binary population.

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Spiral structure in the outer Galactic disk. I. The Third Galactic Quadrant

R. Vazquez ([1]) J. Maj ([2]) G. Carraro ([3]) L. Bronfman ([2]) A. Moitinho ([4]) G. Baume ([1])

([1]) La Plata ([2]) UChile ([3]) ESO ([4]) ULisboa

We combine optical and radio observations to trace the spiral structure in the Third Quadrant of the Milky Way. The optical observations consist of a large sample of young open clusters and associations, whereas the radio observations consist of a survey of nearby and distant clouds observed in CO. Both the optical and radio samples are the largest ones insofar present in the literature. We use this unique material to analyze the behavior of interstellar extinction and to trace the detailed structure of the Third Galactic Quadrant (TGQ).We find that the Outer (Cygnus) grand design spiral arm is traced by stellar and CO components while the Perseus arm is traced solely by CO and is possibly being disrupted by the crossing of the Local (Orion) arm. The Local arm is traced by CO and young stars toward l = 240 degrees and extends for over 8 kpc along the line of sight reaching the Outer arm. Finally, we characterize the Galactic warp and compare the geometries implied by the young stellar and CO components.

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Star cluster life-times: dependence on mass, radius and environment

Mark Gieles ([1]), Henny Lamers ([2]) & Holger Baumgardt ([3])
([1]) ESO/Chile ([2]) Utrecht ([3]) Bonn

The dissolution time (t_{dis}) of clusters in a tidal field does not scale with the "classical" expression for the relaxation time. First, the scaling with N, and hence cluster mass, is shallower due to the finite escape time of stars. Secondly, the cluster half-mass radius is of little importance. This is due to a balance between the relative tidal field strength and internal relaxation, which have an opposite effect on t_{dis}, but of similar magnitude. When external perturbations, such as encounters with giant molecular clouds (GMC) are important, t_{dis} for an individual cluster depends strongly on radius. The mean dissolution time for a population of clusters, however, scales in the same way with mass as for the tidal field, due to the weak dependence of radius on mass. The environmental parameters that determine t_{dis} are the tidal field strength and the density of molecular gas. We compare the empirically derived t_{dis} of clusters in six galaxies to theoretical predictions and argue that encounters with GMCs are the dominant destruction mechanism. Finally, we discuss a number of pitfalls in the derivations of t_{dis} from observations, such as incompleteness, with the cluster system of the SMC as particular example.

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For preprints, contact `mgieles@eso.org`
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The WIYN Open Cluster Study Photometric Binary Survey: Initial Findings for NGC 188

Peter M. Frinchaboy[1] **& Danielle Nielsen**[2]
[1](Univ. of Wisconsin-Madison) [2](UW-REU student from Colby College)

he WIYN open cluster study (WOCS) has been working to yield precise magnitudes in the Johnson-Kron-Cousins UBVRI system for all stars in the field of a selection of "prototypical" open clusters. Additionally, WOCS is using radial velocities to obtain orbit solutions for all cluster binary stars with periods of less than 1000 days. Recently, WOCS is being expanded to include the near-infrared JHK_s (deep ground-based plus 2MASS) and mid-infrared ([3.6], [4.5], [5.8], [8.0]) photometry from Spitzer/IRAC observations. This multi-wavelength data (0.3–8.0 microns) allows us photometrically to identify binaries, with mass ratios from 1.0–0.3, across a wide range of primary masses. The spectral energy distribution (SED) fitter by Robitaille et al. (2007) is used to fit the fluxes of 10–12 bands, converted from the observed magnitudes, to Kurucz stellar models. Using this photometric technique, we find that NGC 188 has a binary fraction of 36–49% and provide a star-by-star comparison to the WOCS radial velocity-based binary study.

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For preprints, contact `frinchaboy@wisc.edu`
Also available from the URL `http://xxx.lanl.gov/abs/0709.2725`
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Young massive star clusters: globular cluster progenitors?

Richard de Grijs
University of Sheffield, UK; and NAOC Beijing, China

I review the long-term survival chances of young massive star clusters (YMCs), hallmarks of intense starburst episodes often associated with violent galaxy interactions. In particular, I address the key question as to whether at least some of these YMCs can be considered proto-globular clusters (GCs). In the absence of significant external perturbations, the key factor determining a cluster's long-term survival chances is the shape of its stellar initial mass function. I conclude that there is an increasing body of evidence that GC formation appears to be continuing until today; their long-term evolution crucially depends on their environmental conditions, however.

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For preprints, contact R.deGrijs@sheffield.ac.uk
Also available from the URL http://arxiv.org/abs/0711.3540
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Pulsating B-type stars in the young open cluster h Persei (NGC 869)

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([1]) Instytut Astronomiczny, Uniwersytet Wroclawski, Wroclaw, Poland ([2]) Konkoly Observatory, Budapest, Hungary

We announce the discovery of six Beta Cephei stars and many other variable stars in the young open cluster h Persei (NGC 869). The cluster seems to be very rich in variable B-type stars, similarly to its twin, Chi Persei (NGC 884).

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For preprints, contact `majewska@astro.uni.wroc.pl`
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The Bologna Open Clusters Chemical Evolution project (in short: BOCCE)

Angela Bragaglia
INAF-Osservatorio Astronomico di Bologna

I present here our project, the Bologna Open Clusters Chemical Evolution (BOCCE) project, aimed at using Open Clusters as tracers of the disk properties and their evolution with time. We are collecting and homogeneously analyzing data, both photometric and spectroscopic, on a large sample of open clusters, representative of the old cluster population, and I show here results obtained on a subset of our clusters.

To appear in : proceedings of "XXI Century challenges for stellar evolution" (Cefalu', Italy), eds. S. Cassisi and M. Salaris, to be published in MemSAIt, 79, 2
For preprints, contact `angela.bragaglia@oabo.inaf.it`
Also available from the URL `http://xxx.lanl.gov/abs/0711.2171`
or by anonymous ftp at `ftp://`

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On the nature of early-type emission line objects in NGC6611.

C. Martayan[1,2], M. Floquet[2], A.-M. Hubert[2], J. Fabregat[3], Y. Frémat[1], D. Baade[4], C. Neiner[2]

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The number and the nature of emission line stars in the young open cluster NGC6611 is still the object of debates. Due to the presence of a strong and variable nebulosity in the cluster, the number of emission line stars is highly depending on the technique and the resolution used for the observations. Thanks to observations with the ESO-WFI, in slitless spectroscopic mode, and with the VLT-GIRAFFE we have been able to disentangle the circumstellar and nebular emissions. We confirm the small number of true emission line objects and we precise their nature: mainly Herbig Be stars.

To appear in : SF2A 2007
For preprints, contact `Martayan@oma.be`
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Galactic & Stellar Dynamics
in the
Era of High Resolution surveys

Strasbourg, France, March 16 to 20, 2008

The *Galactic & Stellar Dynamics* meeting aims to showcase high resolution spectroscopic and photometric observations of nearby galaxies and state-of-the-art theoretical tools (AMR, GPU's, etc) now available for their interpretation and anticipate forthcoming developments.

To reach this broad goal requires to bring together observers and theoreticians to identify problems that likely will be tackled in the near future. To bring out as much from high-resolution data and computer models as possible, this meeting will focus on **local universe galaxies** (z = 0). The high spatial resolution achieved by current observational (AO, MCAO, ..) and theoretical techniques now allows to probe local galaxies at a scale of a few parsecs and reveal details of physics taking place on the smallest scales. It is this vein that we seek to tap in to.

The meeting will take place on the science campus of University Louis Pasteur in Strasbourg, France, from March 16 to 20, 2008.

GSD2008 is sponsored jointly by the French and German national astronomical societies.
The list of topics covered include:

- The stellar (I)MF and ISM in the local universe
  Solar neighbourhood, local star forming regions & associations
- Dynamics & Evolution in Our and Nearby Galaxies
  Bulges & massive black holes, bars, disks, spiral arms, globular cluster systems
- Dynamics of (Nearby) Galaxy Mergers Modelling, low-z mergers & remnants, star forming regions, tidal dwarfs & ellipticals, massive young clusters
- Populations, Dynamics & Stellar Evolution Milky way surveys, GAIA, streams, dwarf galaxies

SOC: F. Combes (Paris), K.Freeman (MSSO), O. Gerhard (Munich), E. Grebel (Heidelberg), D.C. Heggie (Edinburgh), G. Hensler (Vienna), R. Ibata (Strasbourg), D. Merritt (Rochester), B. Moore (Zurich), R. Teyssier (Saclay)

LOC: C.M. Boily (chair), R. Spurzem (co-chair), D. Auber, E. Brunette, R. David, T. Keller, A. Lancon, S. Langenbacher, B. Moya, B. Vollmer

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MPA/ESO/USM/MPE 2008 Joint Astronomy Conference

on

"Chemical Evolution of Dwarf Galaxies and Stellar Clusters"

July 21 - 25 2008 (Garching bei Muenchen, Germany)

FIRST ANNOUNCEMENT

Dear Colleagues,

small stellar systems like dwarf galaxies and galactic clusters might be well suited to study galactic nucleosynthesis and chemical evolution as to a first approximation they can be treated as simple, homogeneous one-component objects.

An intensive effort has been made in the last years in determining stellar abundances in galactic stellar systems (notably globular clusters) and in local-group dwarf galaxies. Many of these projects are actually pursued with the latest instruments, and have revealed surprising results.

Stars in globular clusters on the one hand are characterised be a well-defined iron abundance with a small spread which indicates that they formed from gas that has been pre-enriched. This narrow iron spread is in contrast with the widespread abundance anomalies in light elements which is preferentially explained by "primordial pollution" scenarios. This might imply, at least to some degree, an internal chemical evolution, where presently observed stars formed out of cluster matter polluted by earlier generations of stars, or at least by the more massive objects of the same generation. There are also scenarios which claim that this pollution was due to external field stars in the surrounding of the proto-globular cluster cloud which was part of a small, dwarf-galaxy-like substructure of the Galaxy. This host galaxy was later disrupted by the Milky Way, while its globular clusters survived and are now part of the MW system.

Dwarf galaxies are likely to have formed, as typical for galaxies, through infall of primordial gas into a dark matter halo. They therefore have their own chemical evolution, which, however, is different from that of large galaxies due to the shallower potential wells, leading to more efficient mixing and a strong influence of galactic tides causing harrassement and tidal disruption. In addition, outflows of enriched hot gas in galactic winds are likely to affect these systems. Dwarf galaxies are also investigated in integrated light to derive their star-formation history and age-metallicity relations. Some globular clusters are thought to be cores of former dwarf galaxies, in particular those where multiple populations of stars have been found (such as omega Cen and NGC 2808).

As globular clusters and dwarf galaxies form a mass sequence and in view of the possible connections between the two classes of stellar systems, a confrontation and comparison of cluster and dwarf chemical evolution appears to be interesting and possibly helpful to understand the origin of the abundances in both classes.

We invite you to discuss theoretical and observational aspects of the Chemical Evolution of Dwarf Galaxies and Stellar Clusters in a conference jointly organized by the four major astrophysical institutes of the Munich area: ESO, MPA, MPE and USM. Further and more detailed informations can be found in the conference web page: http://www.mpa-garching.mpg.de/∼garcon08

In order to receive further announcements, please register by March 1, 2008 using our web interface at http://www.mpa-garching.mpg.de/∼garcon08/registration.html

Further communications will be sent only to the registered participants. Since the number of participants will have to be limited, acceptance will be done according to registration date.

Topics:

The scientific program will broadly include:

- Chemical composition (empirical evidence and theoretical models: nuclear arguments, evolutionary possibilities)
- Age-metallicity relation (ages of stellar systems and their subpopulations, dwarf galaxies SFH, ...)
- Origin (creation of dG & clusters: when and where, together?; evidence for common origin; cluster-dwarf assignments)
- Evolution (separation of dG & clusters; tidal interaction with host galaxy, internal evolution)

Location:

The Conference venue is at the Garching Research Center (Garching Forschungszentrum), where MPA, MPE and ESO are located. Given the limited capabilities of the available lecture halls, a maximum of 150 participants is envisaged. The Forschungszentrum area is easily reachable via public transportation. Detailed can be found in the conference web page:
http://www.mpa-garching.mpg.de/ garcon08/travel.html
A list of hotels is available at the conference web site. We have made block reservations in these hotels and would prefer that participants make their hotel arrangements through the conference secretary. Otherwise participants are expected to organize their travel themselves.

Registration fee:

The registration fee is 150 Euros.

Conference format:

The format of the conference will include reviews, talks and posters, but no proceedings book is planned: the authors will be asked to provide their presentations in advance, and a CD containing all presentations will be distributed to the attendants. Rewiew speakers are asked to provide a written contribution, which will be published in the ESO Messenger.

Important dates:

December 10, 2007: First announcement
February 1, 2008: Second announcement
March 1, 2008: Prelimary registration and abstract submission
April 1, 2008: Preliminary program and third announcement
April 15: Registration confirmation; registration closes
June 1: Final Programme and Final announcement
July 21: Starting of the conference

Contacts:

For any additional enquiry, pleasa contact us at: garcon08@mpa-garching.mpg.de