The Star Clusters Young & Old Newsletter

edited by Giovanni Carraro, Martin Netopil, and Ernst Paunzen
http://www.univie.ac.at/scyon/
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The official Newsletter of
the IAU Commission H4.

SCYON Issue No. 72 May 26^{th}, 2017

Dear colleagues,

The quest for clear signatures of the presence of Intermediate Mass Black Holes (IMBHs) in the center of galactic globular clusters keeps being a lively research topic because of its enormous implications for galaxy formation theories. Kinematical and photometric signatures, while initially creating a lot of enthusiasm, are now under close scrutiny and at present not considered anymore conclusive, as nicely described in Zocchi et al. (see abstract in this issue). Again, the promises come from *Gaia*, and the high precision proper motion measurements that the satellite will eventually deliver.

Still, also the question about the determining factors for multiple main sequences of star clusters remain unanswered. New analyses in the Milky Way and the Magellanic Clouds are inconclusive. In these three Galaxies, the widely different metallicities and ages allow to put further constraints on models explaining the formation and evolution of multiple sequences. However, still, more accurate observations are needed to shed more light on this phenomenon.

A wide range of cluster topics are covered by the 19 abstracts in this issue, and we also want to draw your attention to upcoming conferences and a Postdoc job announcement.

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About the Newsletter

SCYON publishes abstracts from any area in astronomy, which are relevant to research on star clusters. We welcome all kinds of submitted contributions (abstracts of refereed papers or conference proceedings, PhD summaries, and general announcements of e.g. conferences, databases, tools, etc.)

The mission of this newsletter is to help all the researchers in the field with a quick and efficient link to the scientific activity in the field. We encourage everybody to contribute to the new releases! New abstracts can be submitted *at any time* using the **webform** on the SCYON homepage.

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Galactic Open Clusters

On the existence of young embedded clusters at high Galactic latitude

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Careful analyses of photometric and star count data available for the nine putative young clusters identified by Camargo et al. (2015, 2016) at high Galactic latitudes reveal that none of the groups contain early-type stars, and most are not significant density enhancements above field level. 2MASS colours for stars in the groups match those of unreddened late-type dwarfs and giants, as expected for contamination by (mostly) thin disk objects. A simulation of one such field using only typical high latitude foreground stars yields a colour-magnitude diagram that is very similar to those constructed by Camargo et al. (2015, 2016) as evidence for their young groups as well as the means of deriving their reddenings and distances. Although some of the fields are coincident with clusters of galaxies, one must conclude that there is no evidence that the putative clusters are extremely young stellar groups.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://adsabs.harvard.edu/abs/2017arXiv170506748T

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An optical and infrared photometric study of the young open cluster IC 1805 in the giant HII region W4

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We present deep wide-feld optical CCD photometry and mid-infrared Spitzer/IRAC and MIPS 24 micron data for about 100,000 stars in the young open cluster IC 1805. The members of IC 1805 were selected from their location in the various color-color and color-magnitude diagrams, and the presence of Halpha emission, mid-infrared excess emission, and X-ray emission. The reddening law toward IC 1805 is nearly normal ($R_V = 3.05 \pm 0.06$). However, the distance modulus of the cluster is estimated to be 11.9 ± 0.2 mag (d = 2.4±0.2 kpc) from the reddening-free color-magnitude diagrams, which is larger than the distance to the nearby massive star-forming region W3(OH) measured from the radio VLBA astrometry. We also determined the age of IC 1805 ($\tau_{\rm MSTO} = 3.5$ Myr). In addition, we critically compared the age and mass scale from two pre-main-sequence evolution models. The initial mass function with a Salpeter-type slope of $\Gamma = -1.3 \pm 0.2$ was obtained and the total mass of IC 1805 was estimated to be about 2700 ± 200 $M_\odot$. Finally, we found our distance determination to be statistically consistent with the Tycho-Gaia Astrometric Solution Data Release 1, within the errors. The proper motion of the B-type stars shows an elongated distribution along the Galactic plane, which could be explained by some of the B-type stars being formed in small clouds dispersed by previous episodes of star formation or supernova explosions.

Accepted by : Astrophysical Journal Supplement Series
http://adsabs.harvard.edu/abs/2017ApJS..230....3S

Rotation of Late-Type Stars in Praesepe with K2

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We have Fourier analyzed 941 K2 light curves of likely members of Praesepe, measuring periods for 86% and increasing the number of rotation periods (P) by nearly a factor of four. The distribution of P vs. $(V-K)$, a mass proxy, has three different regimes: $(V-K)<1.3$, where the rotation rate rapidly slows as mass decreases; $1.3<(V-K)<4.5$, where the rotation rate slows more gradually as mass decreases; and $(V-K)>4.5$, where the rotation rate rapidly increases as mass decreases. In this last regime, there is a bimodal distribution of periods, with few between ∼2 and ∼10 days. We interpret this to mean that once M stars start to slow down, they do so rapidly. The K2 period-color distribution in Praesepe (∼790 Myr) is much different than in the Pleiades (∼125 Myr) for late F, G, K, and early-M stars; the overall distribution moves to longer periods, and is better described by 2 line segments. For mid-M stars, the relationship has similarly broad scatter, and is steeper in Praesepe. The diversity of lightcurves and of periodogram types is similar in the two clusters; about a quarter of the periodic stars in both clusters have multiple significant periods. Multi-periodic stars dominate among the higher masses, starting at a bluer color in Praesepe ($(V-K)\sim1.5$) than in the Pleiades ($(V-K)\sim2.6$). In Praesepe, there are relatively more light curves that have two widely separated periods, ΔP>6 days. Some of these could be examples of M star binaries where one star has spun down but the other has not.

Accepted by : Astrophysical Journal
http://adsabs.harvard.edu/abs/2017ApJ...839...92R

Search for variables in six Galactic open clusters

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Variables in open cluster (known distance, age, and metallicity) fields play an important role in stellar astrophysics because they allow to investigate the interior of stars. Therefore, six Galactic open clusters were selected to search for new variables and to complement data for already known variables. As five of these clusters are younger than 40 Myr, we aim at finding variable high-mass stars such as β Cephei and Slowly Pulsating B-type stars as well as classical pulsating stars within the instability strip. About 26 000 images (312 h) photometric images were taken at the 0.8 m (Vienna, Austria) and 1.0 m (Hvar, Croatia) telescope using V and I filters. The differential light curves were analyzed with standard time series analysis methods. In total, 11 variables were found in all investigated clusters. For nine of them, we were able to determine their nature and period. In addition, the membership probabilities from the literature were analyzed.

Accepted by : New Astronomy
http://adsabs.harvard.edu/abs/2017NewA...52..133P

Metallicity calibrations for dwarf stars and giants in the Geneva photometric system

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We use the most homogeneous Geneva seven-colour photometric system to derive new metallicity calibrations for early A- to K-type stars that cover both, dwarf stars and giants. The calibrations are based on several spectroscopic data sets that were merged to a common scale, and we applied them to open cluster data to obtain an additional proof of the metallicity scale and accuracy. In total, metallicities of 54 open clusters are presented. The accuracy of the calibrations for single stars is in general below 0.1 dex, but for the open cluster sample with mean values based on several stars we find a much better precision, a scatter as low as about 0.03 dex. Furthermore, we combine the new results with another comprehensive photometric data set to present a catalogue of mean metallicities for more than 3000 F and G-type dwarf stars with $\sigma \sim 0.06$ dex. The list was extended by more than 1200 hotter stars up to about 8500 K (or spectral type A3) by taking advantage of their almost reddening free characteristic in the new *Geneva* metallicity calibrations. These two large samples are well suited as primary or secondary calibrators of other data, and we already identified about 20 spectroscopic data sets that show offsets up to about 0.4 dex.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://adsabs.harvard.edu/abs/2017arXiv170500883N

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NGC 6067: a young and massive open cluster with high metallicity

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NGC 6067 is a young open cluster hosting the largest population of evolved stars among known Milky Way clusters in the 50 – 150 Ma age range. It thus represents the best laboratory in our Galaxy to constrain the evolutionary tracks of 5 – 7 $M_\odot$ stars. We have used high-resolution spectra of a large sample of bright cluster members (45), combined with archival photometry, to obtain accurate parameters for the cluster as well as stellar atmospheric parameters. We derive a distance of 1.78 ± 0.12 kpc, an age of 90 ± 20Ma and a tidal radius of $14.8^{+6.8}_{-3.2}$ arcmin. We estimate an initial mass above 5 700 $M_\odot$, for a present-day evolved population of two Cepheids, two A supergiants and 12 red giants with masses $\approx 6\,M_\odot$. We also determine chemical abundances of Li, O, Na, Mg, Si, Ca, Ti, Ni, Rb, Y, and Ba for the red clump stars. We find a supersolar metallicity, [Fe/H]=$+0.19 \pm 0.05$, and a homogeneous chemical composition, consistent with the Galactic metallicity gradient. The presence of a Li-rich red giant, star 276 with A(Li)=2.41, is also detected. An over-abundance of Ba is found, supporting the enhanced *s*-process. The ratio of yellow to red giants is much smaller than one, in agreement with models with moderate overshooting, but the properties of the cluster Cepheids do not seem consistent with current Padova models for supersolar metallicity.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://adsabs.harvard.edu/abs/2017arXiv170401548A

Binarity as the Solution to the Stellar Evolution Enigma Posed by NGC 6791

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Binary evolution is investigated as the source for the extreme horizontal branch (EHB) stars in the old and metal-rich open cluster NGC 6791. Employing an updated version of our binary stellar evolution code, we demonstrate that EHB stars naturally emerge from the common-envelope phase. In sum, the binary model reproduces the observed ($T_{\rm eff}$, log$g$) and temporal properties of the EHB overdensity tied to NGC 6971, without needing an ad hoc and anomalous mass-loss prescription.

Accepted by : Astrophysical Journal Letters
http://adsabs.harvard.edu/abs/2017arXiv170501776C

Galactic Globular Clusters

The "UV-route" to search for Blue Straggler Stars in Globular Clusters: first results from the HST UV Legacy Survey

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We used data from the HST UV Legacy Survey of Galactic Globular Clusters to select the Blue Straggler Star (BSS) population in four intermediate/high density systems (namely NGC 2808, NGC 6388, NGC 6541 and NGC 7078) through a "UV-guided search". This procedure consists in using the F275W images in each cluster to construct the master list of detected sources, and then force it to the images acquired in the other filters. Such an approach optimizes the detection of relatively hot stars and allows the detection of complete sample of BSSs even in the central region of high-density clusters, because the light from the bright cool giants, which dominates the optical emission in old stellar systems, is sensibly reduced at UV wavelengths. Our UV-guided selections of BSSs have been compared to the samples obtained in previous, optical-driven surveys, clearly demonstrating the efficiency of the UV approach. In each cluster we also measured the parameter A+, defined as the area enclosed between the cumulative radial distribution of BSSs and that of a reference population, which traces the level of BSS central segregation and the level of dynamical evolution suffered by the system. The values measured for the four clusters studied in this paper nicely fall along the dynamical sequence recently presented for a sample of 25 clusters.

Accepted by : Astrophysical Journal
http://adsabs.harvard.edu/abs/2017ApJ...839...64R

Far-Ultraviolet Observation of the Globular Cluster NGC 6397

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We present an observational far-UV (FUV) and near-UV (NUV) study of the core region of the globular cluster NGC 6397. The observations were obtained with the Space Telescope Imaging Spectrograph (STIS, FUV), and the Wide Field Camera 3 (WFC3, NUV) on board the Hubble Space Telescope. Here, we focus on the UV bright stellar populations such as blue stragglers (BSs), white dwarfs (WDs) and cataclysmic variables (CVs). We present the first FUV-NUV color-magnitude diagram (CMD) for this cluster. To support our classification of the stellar populations, we compare our FUV-NUV CMD with optical data from the ACS Survey of Galactic Globular Clusters. The FUV-NUV CMD indicates 16 sources located in the WD area, and ten BSs within the $25''\times 25''$of the STIS FUV data. Eighteen Chandra X-ray sources are located within the FUV field of view. Thirteen of those have a NUV counterpart, of which nine sources also have a FUV counterpart. Out of those, five sources are previously suggested CVs, and indeed all five are located in the WD/CV region in our FUV-NUV CMD. Another CV only has a FUV but no NUV counterpart. We also detect a NUV (but no FUV) counterpart to the MSP located in the core of this cluster. The NUV lightcurves of the CVs and MSP show flickering behaviour typical of CVs. We found that the BSs and CVs are the most centrally concentrated population. This might be an effect of mass segregation or indicate the preferred birth place of BSs and CVs via dynamical interactions in the dense core region of GCs. HB stars are the least centrally concentrated population and absent in the innermost area of the core.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://adsabs.harvard.edu/abs/2017arXiv170508770D

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Galactic Orbits of Globular Clusters in the Region of the Galactic Bulge

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Galactic orbits have been constructed over long time intervals for ten globular clusters located near the Galactic center. A model with an axially symmetric gravitational potential for the Galaxy was initially applied, after which a non-axially symmetric potential corresponding to the central bar was added. Variations in the trajectories of all these globular clusters in the XY plane due to the influence of the bar were detected. These were greatest for the cluster Terzan 4 in the meridional (RZ) plane. The globular clusters Terzan1, Terzan2, Terzan4, Terzan9, NGC 6522, and NGC 6558 always remained within the Galactic bulge, no farther than 4 kpc from the Galactic center.

Accepted by : Astronomy Reports
http://adsabs.harvard.edu/abs/2017arXiv170505329B

Clusters in the Magellanic clouds

Stellar clusterings around "Isolated" Massive YSOs in the LMC

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Observations suggest that there is a significant fraction of O-stars in the field of the Milky Way that appear to have formed in isolation or in low mass clusters (<100 $M_\odot$). The existence of these high-mass stars that apparently formed in the field challenges the generally accepted paradigm, which requires star formation to occur in clustered environments. In order to understand the physical conditions for the formation of these stars, it is necessary to observe isolated high-mass stars while they are still forming. With the Hubble Space Telescope, we observe the seven most isolated massive (>8 $M_\odot$) young stellar objects (MYSOs) in the Large Magellanic Cloud (LMC). The observations show that while these MYSOs are remote from other MYSOs, OB associations, and even from known giant molecular clouds, they are actually not isolated at all. Imaging reveals ∼100 to several hundred pre–main-sequence (PMS) stars in the vicinity of each MYSO. These previously undetected PMS stars form prominent compact clusters around the MYSOs, and in most cases they are also distributed sparsely across the observed regions. Contrary to what previous high-mass field star studies show, these observations suggest that high-mass stars may not be able to form in clusters with masses less than 100 $M_\odot$. If these MYSOs are indeed the best candidates for isolated high-mass star formation, then the lack of isolation is at odds with random sampling of the IMF. Moreover, while isolated MYSOs may not exist, we find evidence that isolated clusters containing O-stars can exist, which in itself is rare.

Accepted by : Astrophysical Journal
http://adsabs.harvard.edu/abs/2017ApJ...834...94S

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The Search for Multiple Populations in Magellanic Cloud Clusters III: No evidence for Multiple Populations in the SMC cluster NGC 419

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We present the third paper about our ongoing HST survey for the search for multiple stellar populations (MPs) within Magellanic Cloud clusters. We report here the analysis of NGC 419, a ~ 1.5 Gyr old, massive ($\gtrsim 2 \times 10^5$ $M_\odot$) star cluster in the Small Magellanic Cloud (SMC). By comparing our photometric data with stellar isochrones, we set a limit on [N/Fe] enhancement of $\lesssim$+0.5 dex and hence we find that no MPs are detected in this cluster. This is surprising because, in the first two papers of this series, we found evidence for MPs in 4 other SMC clusters (NGC 121; Lindsay 1, NGC 339, NGC 416), aged from 6 Gyr up to $\sim 10-11$ Gyr. This finding raises the question whether age could play a major role in the MPs phenomenon. Additionally, our results appear to exclude mass or environment as the only key factors regulating the existence of a chemical enrichment, since all clusters studied so far in this survey are equally massive ($\sim 1-2 \times 10^5$ $M_\odot$) and no particular patterns are found when looking at their spatial distribution in the SMC.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://adsabs.harvard.edu/abs/2017MNRAS.468.3150M

The most distant clusters

Searching for GC-like abundance patterns in young massive clusters II. - Results from the Antennae galaxies

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The presence of multiple populations (MPs) with distinctive light element abundances is a widespread phenomenon in clusters older than 6 Gyr. Clusters with masses, luminosities, and sizes comparable to those of ancient globulars are still forming today. Nonetheless, the presence of light element variations has been poorly investigated in such young systems, even if the knowledge of the age at which this phenomenon develops is crucial for theoretical models on MPs. We use J-band integrated spectra of three young (∼7-40 Myr) clusters in NGC 4038 to look for Al variations indicative of MPs. Assuming that the large majority (>70%) of stars are characterised by high Al content - as observed in Galactic clusters with comparable mass; we find that none of the studied clusters show significant Al variations. Small Al spreads have been measured in all the six young clusters observed in the near-infrared. While it is unlikely that young clusters only show low Al whereas old ones display different levels of Al variations; this suggests the possibility that MPs are not present at such young ages at least among the high-mass stellar component. Alternatively, the fraction of stars with field-like chemistry could be extremely large, mimicking low Al abundances in the integrated spectrum. Finally, since the near-infrared stellar continuum of young clusters is almost entirely due to luminous red supergiants, we can also speculate that MPs only manifest themselves in low mass stars due to some evolutionary mechanism.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://adsabs.harvard.edu/abs/2017MNRAS.468.2482L

Panchromatic Hubble Andromeda Treasury XVIII. The High-mass Truncation of the Star Cluster Mass Function

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We measure the mass function for a sample of 840 young star clusters with ages between 10 and 300 Myr observed by the Panchromatic Hubble Andromeda Treasury (PHAT) survey in M31. The data show clear evidence of a high-mass truncation: only 15 clusters more massive than 10^4 $M_\odot$ are observed, compared to the ∼100 expected for a canonical M^{-2} pure power-law mass function with the same total number of clusters above the catalog completeness limit. Adopting a Schechter function parameterization, we fit a characteristic truncation mass of $M_c = 8.5^{+2.8}_{-1.8} \times 10^3$ $M_\odot$. Although previous studies have measured cluster mass function truncations, the characteristic truncation mass we measure is the lowest ever reported. Combining this M31 measurement with previous results, we find that the cluster mass function truncation correlates strongly with the characteristic star formation rate surface density of the host galaxy, where $M_c \propto \langle \Sigma_{\rm SFR} \rangle^{\sim 1.1}$. We also find evidence that suggests the observed M_c–$\Sigma_{\rm SFR}$ relation also applies to globular clusters, linking the two populations via a common formation pathway. If so, globular cluster mass functions could be useful tools for constraining the star formation properties of their progenitor host galaxies in the early universe.

Accepted by : Astrophysical Journal
http://adsabs.harvard.edu/abs/2017ApJ...839...78J

Dynamical evolution - Simulations

Radial anisotropy in omega Cen limiting the room for an intermediate-mass black hole

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Finding an intermediate-mass black hole (IMBH) in a globular cluster (or proving its absence) would provide valuable insights into our understanding of galaxy formation and evolution. However, it is challenging to identify a unique signature of an IMBH that cannot be accounted for by other processes. Observational claims of IMBH detection are indeed often based on analyses of the kinematics of stars in the cluster core, the most common signature being a rise in the velocity dispersion profile towards the centre of the system. Unfortunately, this IMBH signal is degenerate with the presence of radially-biased pressure anisotropy in the globular cluster. To explore the role of anisotropy in shaping the observational kinematics of clusters, we analyse the case of omega Cen by comparing the observed profiles to those calculated from the family of LIMEPY models, that account for the presence of anisotropy in the system in a physically motivated way. The best-fit radially anisotropic models reproduce the observational profiles well, and describe the central kinematics as derived from Hubble Space Telescope proper motions without the need for an IMBH.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://adsabs.harvard.edu/abs/2017arXiv170200725Z

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Kinematical evolution of tidally limited star clusters: rotational properties

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We present the results of a set of N-body simulations following the long-term evolution of the rotational properties of star cluster models evolving in the external tidal field of their host galaxy, after an initial phase of violent relaxation. The effects of two-body relaxation and escape of stars lead to a redistribution of the ordered kinetic energy from the inner to the outer regions, ultimately determining a progressive general loss of angular momentum; these effects are reflected in the overall decline the rotation curve as the cluster evolves and loses stars. We show that all of our models share the same dependence of the remaining fraction of the initial rotation on the fraction of the initial mass lost. As the cluster evolves and loses part of its initial angular momentum, it becomes increasingly dominated by random motions, but even after several tens of relaxation times, and losing a significant fraction of its initial mass, a cluster can still be characterized by a non-negligible ratio of the rotational velocity to the velocity dispersion. This result is in qualitative agreement with the recently observed kinematical complexity which characterizes several Galactic globular clusters.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://adsabs.harvard.edu/abs/2017arXiv170405918T

Dynamical Properties of Eccentric Nuclear Disks: Stability, Longevity, and Implications for Tidal Disruption Rates in Post-Merger Galaxies

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In some galaxies, the stars orbiting the supermassive black hole take the form of an eccentric nuclear disk, in which every star is on a coherent, apsidally-aligned orbit. The most famous example of an eccentric nuclear disk is the double nucleus of Andromeda, and there is strong evidence for many more in the local universe. Despite their apparent ubiquity however, a dynamical explanation for their longevity has remained a mystery: differential precession should wipe out large-scale apsidal-alignment on a short timescale. Here we identify a new dynamical mechanism which stabilizes eccentric nuclear disks. We predict the existence of an outer secondary disk and for the first time explain the negative eccentricity gradient seen in the Andromeda nucleus. The stabilizing mechanism drives oscillations of the eccentricity vectors of individual orbits, both in direction (about the mean body of the disk) and in magnitude. Combined with the negative eccentricity gradient, the eccentricity oscillations push some stars near the inner edge of the disk extremely close to the black hole, potentially leading to tidal disruption events. Order of magnitude calculations predict extremely high rates in recently-merged galaxies ($\sim$0.1 – 1 per year per galaxy). Unless the stellar disks are replenished, these rates should decrease with time as the disk depletes in mass. This may explain the preferential occurrence of tidal disruption events in recently-merged and post-merger (E+A/K+A) galaxies.

Submitted to : Astrophysical Journal
http://adsabs.harvard.edu/abs/2017arXiv170503462M

Miscellaneous

A unified model for the maximum mass-scales of molecular clouds, stellar clusters, and high-redshift clumps

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We present a simple, self-consistent model to predict the maximum masses of giant molecular clouds (GMCs), stellar clusters and high-redshift clumps as a function of the galactic environment. Recent works have proposed that these maximum masses are set by shearing motions and centrifugal forces, but we show that this idea is inconsistent with the low masses observed across an important range of local-Universe environments, such as low-surface density galaxies and galaxy outskirts. Instead, we propose that feedback from young stars can disrupt clouds before the global collapse of the shear-limited area is completed. We develop a shear-feedback hybrid model that depends on three observable quantities: the gas surface density, the epicylic frequency, and the Toomre parameter. The model is tested in four galactic environments: the Milky Way, the Local Group galaxy M31, the spiral galaxy M83, and the high-redshift galaxy zC406690. We demonstrate that our model simultaneously reproduces the observed maximum masses of GMCs, clumps and clusters in each of these environments. We find that clouds and clusters in M31 and in the Milky Way are feedback-limited beyond radii of 8.4 and 4 kpc, respectively, whereas the masses in M83 and zC406690 are shear-limited at all radii. In zC406690, the maximum cluster masses decrease further due to their inspiral by dynamical friction. These results illustrate that the maximum masses change from being shear-limited to being feedback-limited as galaxies become less gas-rich and evolve towards low shear. This explains why high-redshift clumps are more massive than GMCs in the Local Universe.

Accepted by : Monthly Notices of the Royal Astronomical Society
http://adsabs.harvard.edu/abs/2017arXiv170400732R

Proceedings abstracts

Clusterix 2.0 for Gaia

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We present an advanced, VO-compliant version of Clusterix, a tool for the determination of membership probabilities in stellar clusters from proper motion data. Clusterix is a web-based, interactive application that allows the computation of membership probabilities from proper motions through a fully non-parametric method. Version 1.0 (http://clusterix.cerit-sc.cz/) was developed as a collaboration between the Masaryk University (Czech Republic) and the Universitat de Barcelona (Spain), as a complement to the WEBDA (http://webda.physics.muni.cz) database of observational data on stars in open clusters. Clusterix 2.0 (http://clusterix.cab.inta-csic.es/clusterix/) is oriented towards the exploitation of Gaia data products. With the participation of the Spanish Virtual Observatory, Clusterix now features an improved user interface for a faster, easier and more accurate interactive definition of the cluster and field proper motion distributions. The system provides fast feedback between membership probability determinations and the distribution of observables for the most probable members and field stars, with graphic tools to display, for instance, photometric diagrams on the fly. Furthermore, Clusterix 2.0 is fully VO-compatible, what opens interesting prospects for the astrophysical exploitation of the improved membership probabilities that will be capable to provide for many open clusters observed by Gaia.

To appear in : Highlights on Spanish Astrophysics IX, Proceedings of the XII Scientific Meeting of the Spanish Astronomical Society held on July 18-22, 2016, in Bilbao, Spain
http://adsabs.harvard.edu/abs/2017hsa9.conf..328B

Conferences

Stellar Populations and the Distance Scale

11–15 September, 2017
Beijing, China
http://kiaa.pku.edu.cn/stpop2017/

MODEST 17 - Modelling and observing dense stellar systems

18–22 September, 2017
Prague, Czech Republic
http://astro.mff.cuni.cz/events/modest17/

early registration / abstract deadline: June 30^{th} 2017

Jobs

Post-doctoral fellowship
at Laboratoire d'Astrophysique de Bordeaux
Bordeaux University, France

Physical properties of evolved open clusters in the Gaia era

The Laboratoire d'Astrophysique de Bordeaux (LAB) invites applications for a postdoctoral position related to the scientific exploitation of Gaia Data Release 2 to be published in April 2018.

The ESA Gaia satellite has been scanning the sky since mid-2014, providing the most extensive astrometric, photometric and spectroscopic survey of our Galaxy to date, revealing the 3D distribution and space motions of more than one billion stars. In particular Gaia will enable a new type of exploration of open clusters which are fundamental objects to trace the history of the galactic disc and to test theories of star formation and evolution. Open clusters have also received much attention from the ground and a huge amount of valuable observing material is available for analysis.

The successful candidate will work on a project entitled 'Physical properties of evolved open clusters in the Gaia era' funded by CNES, the French spatial agency. The aim is to determine the physical properties of nearby old open clusters using the Gaia astrometry combined with photometric and spectroscopic data available from Gaia and from the ground. The project will provide new insights on how OCs dissolve and populate the Galactic field. It will also provide a list of benchmark objects with updated member lists and well-determined properties to be used for the validation of stellar evolution theories. The candidate will join an international group of experts in stellar physics and galactic archeology collaborating on this project.

Applicants should hold a PhD degree in astronomy and are expected to have a solid experience in galactic archeology and stellar spectroscopy. Familiarity with data management and organization would be an asset.

The LAB is located in a university campus, in the Bordeaux metropolitan area. About 30 astronomers work on a variety of astrophysical topics, ranging from planetary surfaces and atmospheres to star formation and extragalactic astrophysics. The beautiful city of Bordeaux offers one of the highest quality of living and a vibrant cultural life, near the Atlantic coast.

The net monthly salary between EUR 2363 and 2817 will depend on previous experience. The contract administrated by CNRS will carry all social benefits stipulated in French law employment such as social security, maternity/parental leave, sick leave, holidays leave...

Applications should include a cover letter and curriculum vitae, including statements on education and research experience. The documents should be merged into a single PDF to be sent to Caroline Soubiran (caroline.soubiran@u-bordeaux.fr). Applicants should arrange for three letters of recommendation to be sent to the same address.

Duration: 2 years
Application deadline: September 15, 2017

Contact: Dr. Caroline Soubiran, `caroline.soubiran@u-bordeaux.fr`**.**