The Star Clusters Young & Old Newsletter

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Dear colleagues,

This is already the 10^{th} issue of the newsletter by the current editor team, thus time for a short review. Although the number of subscribers has increased to about 570 researchers, the number of submitted abstracts remained on a similar level. Therefore, the initial plan to publish the newsletter more often than on a quarterly basis is still not practicable. We want to remind you that SCYON also offers a discussion forum (`http://www.univie.ac.at/scyon/forum.html`). Unfortunately, this possibility to get in contact with the community, but also the Facebook group by Michael Marks "Star Clusters on arXiv", is little used. Both are perfect places to share ideas, establish new collaborations, and to further boost the activity of the star cluster community.

This issue includes 28 abstracts, among them several results from large surveys such as Gaia-ESO, RAVE, and VVV. Most of these results will be hopefully soon complemented by the first data of the Gaia mission. The activity of our community is highlighted by the announcements of five conferences and workshops which cover topics of the very early to the very late stages of stellar clusters, both from the observational and theoretical point-of-view. There is also a new version of the extensively used DAML02 Catalogue by Wilton Dias announced. Furthermore, we want to draw your attention to Job offers at the Universidad de Atacama (Chile).

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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.

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

Star Forming Regions

Spectroscopic Binaries in the Orion Nebula Cluster and NGC 2264

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We examine the spectroscopic binary population for two massive nearby regions of clustered star formation, the Orion Nebula Cluster and NGC 2264, supplementing the data presented by Tobin et al. (2009, 2015) with more recent observations and more extensive analysis. The inferred multiplicity fraction up to 10 AU based on these observations is 5.3±1.2% for NGC 2264 and 5.8±1.1% for the ONC; they are consistent with the distribution of binaries in the field in the relevant parameter range. Eight of the multiple systems in the sample have enough epochs to make an initial fit for the orbital parameters. Two of these sources are double-lined spectroscopic binaries; for them we determine the mass ratio. Our reanalysis of the distribution of stellar radial velocities towards these clusters presents a significantly better agreement between stellar and gas kinematics than was previously thought.

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The Massive Stellar Population of W49: A Spectroscopic Survey

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Massive stars form on different scales ranging from large, dispersed OB associations to compact, dense starburst clusters. The complex structure of regions of massive star formation, and the involved short timescales provide a challenge for our understanding of their birth and early evolution. As one of the most massive and luminous star-forming region in our Galaxy, W49 is the ideal place to study the formation of the most massive stars. By classifying the massive young stars deeply embedded into the molecular cloud of W49, we aim to investigate and trace the star formation history of this region. We analyse near-infrared K-band spectroscopic observations of W49 from LBT/LUCI combined with JHK images obtained with NTT/SOFI and LBT/LUCI. Based on JHK-band photometry and K-band spectroscopy the massive stars are placed in a Hertzsprung Russell diagram. By comparison with evolutionary models, their age and hence the star formation history of W49 can be investigated. Fourteen O type stars as well as two young stellar objects (YSOs) are identified by our spectroscopic survey. Eleven O-stars are main sequence stars with subtypes ranging from O3 to O9.5, with masses ranging from ∼20 $M_\odot$ to ∼120 $M_\odot$. Three of the O-stars show strong wind features, and are considered to be Of-type supergiants with masses beyond 100 $M_\odot$. The two YSOs show CO emission, indicative for the presence of circumstellar disks in the central region of the massive cluster. The age of the cluster is estimated as ∼1.5 Myr, with star formation still ongoing in different parts of the region. The ionising photons from the central massive stars have not yet cleared the molecular cocoon surrounding the cluster. W49 is comparable to extragalactic star-forming regions and provides us with an unique possibility to study a starburst in detail.

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Galactic Open Clusters

The Gaia-ESO Survey: Stellar radii in the young open clusters NGC 2264, NGC 2547, and NGC 2516

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Rapidly rotating, low-mass members of eclipsing binary systems have measured radii that are significantly larger than predicted by standard evolutionary models. It has been proposed that magnetic activity is responsible for this radius inflation. By estimating the radii of low-mass stars in three young clusters (NGC 2264, NGC 2547, NGC 2516, with ages of ∼5, ∼35 and ∼140 Myr respectively), we aim to establish whether similar radius inflation is seen in single, magnetically active stars. We use radial velocities from the Gaia-ESO Survey (GES) and published photometry to establish cluster membership and then combine GES measurements of projected equatorial velocities with published rotation periods to estimate the average radii for groups of fast-rotating cluster members as a function of their luminosity and age. The average radii are compared with the predictions of both standard evolutionary models and variants that include magnetic inhibition of convection and starspots. At a given luminosity, the stellar radii in NGC 2516 and NGC 2547 are larger than predicted by standard evolutionary models at the ages of these clusters. The discrepancy is least pronounced and not significant (≃10 per cent) in zero age main sequence stars with radiative cores, but more significant in lower-mass, fully convective pre main-sequence cluster members, reaching ≃30 ± 10 per cent. The uncertain age and distance of NGC 2264 preclude a reliable determination of any discrepancy for its members. The median radii we have estimated for low-mass fully convective stars in the older clusters are inconsistent (at the 2-3σ level) with non-magnetic evolutionary models and more consistent with models that incorporate the effects of magnetic fields or dark starspots. The available models suggest this requires either surface magnetic fields exceeding 2.5 kG, spots that block about 30 per cent of the photospheric flux, or a more moderate combination of both.

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`http://adsabs.harvard.edu/abs/2016A%26A...586A..52J`

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Evidence of the Galactic outer ring R_1R_2' from young open clusters and OB-associations

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The distribution of young open clusters in the Galactic plane within 3 kpc from the Sun suggests the existence of the outer ring R_1R_2' in the Galaxy. The optimum value of the solar position angle with respect to the major axis of the bar, θ_b, providing the best agreement between the distribution of open clusters and model particles is θ_b=35 ± 10 degrees. The kinematical features obtained for young open clusters and OB-associations with negative Galactocentric radial velocity V_R indicate the solar location near the descending segment of the outer ring R_2.

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`http://arxiv.org/abs/1601.01282`

An extensive radial velocity survey towards NGC 6253

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The old and metal-rich open cluster NGC 6253 was observed with the Fibre Large Array Multi Element Spectrograph (FLAMES) multi-object spectrograph during an extensive radial velocity campaign monitoring 317 stars with a median of 15 epochs per object. All the targeted stars are located along the upper main sequence of the cluster between $14.8 < V < 16.5$. Fifty nine stars are confirmed cluster members both by radial velocities and proper motions and do not show evidence of variability. We detected 45 variable stars among which 25 belong to NGC 6253. We were able to derive an orbital solution for four cluster members (and for two field stars) yielding minimum masses in between ∼90 M_J and ∼46 M_J and periods between 3 and 220 d. Simulations demonstrated that this survey was sensitive to objects down to 30 M_J at 10 days orbital periods with a detection efficiency equal to 50 per cent. On the basis of these results we concluded that the observed frequency of binaries down to the hydrogen burning limit and up to 20 d orbital period is around (1.5 ± 1.3) per cent in NGC 6253. The overall observed frequency of binaries around the sample of cluster stars is (13 ± 3) per cent. The median radial velocity precision achieved by the GIRAFFE spectrograph in this magnitude range was around ∼240 $m\,s^{-1}$ (∼180 $m\,s^{-1}$ for UVES). Based on a limited follow-up analysis of seven stars in our sample with the High Accuracy Radial velocity Planet Searcher (HARPS) spectrograph we determined that a precision of 35 $m\,s^{-1}$ can be reached in this magnitude range, offering the possibility to further extend the variability analysis into the substellar domain. Prospects are even more favourable once considering the upcoming ESPRESSO spectrograph at VLT.

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`http://adsabs.harvard.edu/abs/2016MNRAS.457.2722M`

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A search for white dwarfs in the Galactic plane: the field and the open cluster population

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We investigated the prospects for systematic searches of white dwarfs at low Galactic latitudes, using the VLT Survey Telescope H-alpha Photometric Survey of the Galactic plane and Bulge (VPHAS+). We targeted 17 white dwarf candidates along sightlines of known open clusters, aiming to identify potential cluster members. We confirmed all the 17 white dwarf candidates from blue/optical spectroscopy, and we suggest five of them to be likely cluster members. We estimated progenitor ages and masses for the candidate cluster members, and compare our findings to those for other cluster white dwarfs. A white dwarf in NGC 3532 is the most massive known cluster member (1.13 $M_\odot$), likely with an oxygen-neon core, for which we estimate an $8.8^{+1.2}_{-4.3}$ $M_\odot$ progenitor, close to the mass-divide between white dwarf and neutron star progenitors. A cluster member in Ruprecht 131 is a magnetic white dwarf, whose progenitor mass exceeded 2-3 $M_\odot$. We stress that wider searches, and improved cluster distances and ages derived from data of the ESA Gaia mission, will advance the understanding of the mass-loss processes for low- to intermediate-mass stars.

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The Gaia-ESO Survey: membership and Initial Mass Function of the γ Velorum cluster

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Understanding the properties of young open clusters, such as the Initial Mass Function (IMF), star formation history and dynamic evolution, is crucial to obtain reliable theoretical predictions of the mechanisms involved in the star formation process. We want to obtain a list, as complete as possible, of confirmed members of the young open cluster γ Velorum, with the aim of deriving general cluster properties such as the IMF. We used all available spectroscopic membership indicators within the Gaia-ESO public archive together with literature photometry and X-ray data and, for each method, we derived the most complete list of candidate cluster members. Then, we considered photometry, gravity and radial velocities as necessary conditions to select a subsample of candidates whose membership was confirmed by using the lithium and Hα lines and X-rays as youth indicators. We found 242 confirmed and 4 possible cluster members for which we derived masses using very recent stellar evolutionary models. The cluster IMF in the mass range investigated in this study shows a slope of $\alpha = 2.6 \pm 0.5$ for $0.5 < M/M_{\odot} < 1.3$ and $\alpha = 1.1 \pm 0.4$ for $0.16 < M/M_{\odot} < 0.5$ and is consistent with a standard IMF. The similarity of the IMF of the young population around γ^2 Vel to that in other star forming regions and the field suggests it may have formed through very similar processes.

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On the metallicity of open clusters. III. Homogenised sample

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Open clusters are known as excellent tools for various topics in Galactic research. For example, they allow accurately tracing the chemical structure of the Galactic disc. However, the metallicity is known only for a rather low percentage of the open cluster population, and these values are based on a variety of methods and data. Therefore, a large and homogeneous sample is highly desirable. In the third part of our series we compile a large sample of homogenised open cluster metallicities using a wide variety of different sources. These data and a sample of Cepheids are used to investigate the radial metallicity gradient, age effects, and to test current models. We used photometric and spectroscopic data to derive cluster metallicities. The different sources were checked and tested for possible offsets and correlations. In total, metallicities for 172 open cluster were derived. We used the spectroscopic data of 100 objects for a study of the radial metallicity distribution and the age-metallicity relation. We found a possible increase of metallicity with age, which, if confirmed, would provide observational evidence for radial migration. Although a statistical significance is given, more studies are certainly needed to exclude selection effects, for example. The comparison of open clusters and Cepheids with recent Galactic models agrees well in general. However, the models do not reproduce the flat gradient of the open clusters in the outer disc. Thus, the effect of radial migration is either underestimated in the models, or an additional mechanism is at work.

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Massive open star clusters using the VVV survey V. Young clusters with an OB stellar population

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The ESO public survey VISTA Variables in the Vía Láctea (VVV) has contributed with deep multi-epoch photometry of the Galactic bulge and the adjacent part of the disk over 526 square degrees. More than a hundred cluster candidates have been reported thanks to this survey. We present the fifth article in a series of papers focused on young and massive clusters discovered in the VVV survey. In this paper, we present the physical characterization of five clusters with a spectroscopically confirmed OB-type stellar population. To characterize the clusters, we used near-infrared photometry (J, H and K_s) from the VVV survey and near-infrared K-band spectroscopy from ISAAC at VLT, following the methodology presented in the previous articles of the series. All clusters in our sample are very young (ages between 1–20 Myr), and their total mass are between $(1.07^{+0.40}_{-0.30}).10^2$ $M_\odot$ and $(4.17^{+4.15}_{-2.08}).10^3$ $M_\odot$. We observed a relation between the clusters total mass M_{ecl} and the mass of their most massive stellar member m_{max}, even for clusters with an age < 10 Myr.

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GeMs/GSAOI observations of La Serena 94: an old and far open cluster inside the solar circle

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Physical properties were derived for the candidate open cluster La Serena 94, recently unveiled by the VISTA Variables in the Va Lctea (VVV) survey. Thanks to the exquisite angular resolution provided by Gemini South multiconjugate adaptive optics system/Gemini South Adaptive Optics Imager (GeMS/GSAOI), we could characterize this system in detail, for the first time, with deep photometry in JHKs bands. Decontaminated JHKs diagrams reach about 5 mag below the cluster turnoff in H. The locus of red clump giants in the colour-colour diagram, together with an extinction law, was used to obtain an average extinction of $A_V = 14.18 \pm 0.71$. The same stars were considered as standard candles to derive the cluster distance, 8.5 ± 1.0 kpc. Isochrones were matched to the cluster colour-magnitude diagrams to determine its age, log t(yr) = 9.12 ± 0.06, and metallicity, Z = 0.02 ± 0.01. A core radius of $r_c = 0.51 \pm 0.04$ pc was found by fitting King models to the radial density profile. By adding up the visible stellar mass to an extrapolated mass function, the cluster mass was estimated as M=$(2.65 \pm 0.57) \times 10^3$ $M_\odot$, consistent with an integrated magnitude of M_{K_s}=-5.82 ± 0.16 and a tidal radius of $r_t = 17.2 \pm 2.1$ pc. The overall characteristics of La Serena 94 confirm that it is an old open cluster located in the Crux spiral arm towards the fourth Galactic quadrant and distant 7.30 ± 0.49 kpc from the Galactic Centre. The cluster distorted structure, mass segregation and age indicate that it is a dynamically evolved stellar system.

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`http://adsabs.harvard.edu/abs/2016MNRAS.456.2126S`

Open-cluster density profiles derived using a kernel estimator

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Surface and spatial radial density profiles in open clusters are derived using a kernel estimator method. Formulae are obtained for the contribution of every star into the spatial density profile. The evaluation of spatial density profiles is tested against open-cluster models from N-body experiments with N = 500. Surface density profiles are derived for seven open clusters (NGC 1502, 1960, 2287, 2516, 2682, 6819 and 6939) using Two-Micron All-Sky Survey data and for different limiting magnitudes. The selection of an optimal kernel half-width is discussed. It is shown that open-cluster radius estimates hardly depend on the kernel half-width. Hints of stellar mass segregation and structural features indicating cluster non-stationarity in the regular force field are found. A comparison with other investigations shows that the data on open-cluster sizes are often underestimated. The existence of an extended corona around the open cluster NGC 6939 was confirmed. A combined function composed of the King density profile for the cluster core and the uniform sphere for the cluster corona is shown to be a better approximation of the surface radial density profile.The King function alone does not reproduce surface density profiles of sample clusters properly. The number of stars, the cluster masses and the tidal radii in the Galactic gravitational field for the sample clusters are estimated. It is shown that NGC 6819 and 6939 are extended beyond their tidal surfaces.

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The Binary Fraction and Mass Segregation in Alpha Persei Open Cluster

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We have obtained membership probabilities of stars within a field of radius $\sim 3^\circ$ around the centre of the open cluster Alpha Persei using proper motions and photometry from the PPMXL and WISE catalogues. We have identified 810 possible stellar members of Alpha Persei. We derived the global and radial present-day mass function (MF) of the cluster and found that they are well matched by two-stage power-law relations with different slopes at different radii. The global MF of Alpha Persei shows a turnover at $m = 0.62\,\mathrm{M}_\odot$ with low and high-mass slopes of $\alpha_{\rm low} = 0.50 \pm 0.09$ ($0.1 < m/\mathrm{M}_\odot < 0.62$) and $\alpha_{\rm high} = 2.32 \pm 0.14$ ($0.62 \leq m/\mathrm{M}_\odot < 4.68$) respectively. The high-mass slope of the cluster increases from 2.01 inside $1\overset{\circ}{.}10$ to 2.63 outside $2\overset{\circ}{.}2$, whereas the mean stellar mass decreases from 0.95 to $0.57\,\mathrm{M}_\odot$ in the same regions, signifying clear evidence of mass segregation in the cluster. From an examination of the high-quality colour-magnitude data of the cluster and performing a series of Monte Carlo simulations we obtained a binary fraction of $f_{\rm bin} = 34 \pm 12$ percent for stars with $0.70 < m/\mathrm{M}_\odot < 4.68$. This is significantly larger than the observed binary fraction, indicating that this open cluster contains a large population of unresolved binaries. Finally, we corrected the mass-function slopes for the effect of unresolved binaries and found low- and high-mass slopes of $\alpha_{\rm low} = 0.89 \pm 0.11$ and $\alpha_{\rm high} = 2.37 \pm 0.09$ and a total cluster mass of $352\,\mathrm{M}_\odot$.

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The Gaia-ESO Survey: Sodium and aluminium abundances in giants and dwarfs - Implications for stellar and Galactic chemical evolution

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Stellar evolution models predict that internal mixing should cause some sodium overabundance at the surface of red giants more massive than $\sim$ 1.5-2.0 $M_{\odot}$. The surface aluminium abundance should not be affected. Nevertheless, observational results disagree about the presence and/or the degree of the Na and Al overabundances. In addition, Galactic chemical evolution models adopting different stellar yields lead to quite different predictions for the behavior of [Na/Fe] and [Al/Fe] versus [Fe/H]. Overall, the observed trends of these abundances with metallicity are not well reproduced. We readdress both issues, using new Na and Al abundances determined within the Gaia-ESO Survey. Our aim is to obtain better observational constraints on the behavior of these elements using two samples: i) more than 600 dwarfs of the solar neighborhood and of open clusters and ii) low- and intermediate-mass clump giants in six open clusters. Abundances were determined using high-resolution UVES spectra. The individual Na abundances were corrected for nonlocal thermodynamic equilibrium effects. For the Al abundances, the order of magnitude of the corrections was estimated for a few representative cases. For the giants, the abundance trends with stellar mass are compared to stellar evolution models. For the dwarfs, the abundance trends with metallicity and age are compared to detailed chemical evolution models. Abundances of Na in giants with mass below $\sim$2.0 $M_{\odot}$, and of Al in giants below $\sim$3.0 $M_{\odot}$, seem to be unaffected by internal mixing processes. For more massive giants, the Na overabundance increases with stellar mass. This trend agrees well with predictions of stellar evolutionary models. For Al, our only cluster with giants more massive than 3.0 $M_{\odot}$, NGC 6705, is Al enriched. However, this might be related to the environment where the cluster was formed. Chemical evolution models that are able to fit well the observed [Na/Fe] vs. [Fe/H] trend in solar neighborhood dwarfs can not simultaneously explain the run of [Al/Fe] with [Fe/H], and viceversa. The comparison with stellar ages is hampered by severe uncertainties. Indeed, reliable age estimates are available for only a half of the stars of the sample. We conclude that Al is underproduced by the models, except for stellar ages younger than about 7 Gyr. In addition, some significant source of late Na production seems to be missing in the models. Either current Na and Al yields are affected by large uncertainties, and/or some important Galactic source(s) of these elements has not been taken into account up to now.

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Galactic Globular Clusters

Identification of Globular Cluster Stars in RAVE data II: Extended tidal debris around NGC 3201

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We report the identification of extended tidal debris potentially associated with the globular cluster NGC 3201, using the RAVE catalogue. We find the debris stars are located at a distance range of 1–7 kpc based on the forthcoming RAVE distance estimates.The derived space velocities and integrals of motion show interesting connections to NGC 3201, modulo uncertainties in the proper motions. Three stars, which are among the 4 most likely candidates for NGC 3201 tidal debris, are separated by 80 degrees on the sky yet are well matched by the 12 Gyr, [Fe/H] $= -1.5$ isochrone appropriate for the cluster. This is the first time tidal debris around this cluster has been reported over such a large spatial extent, with implications for the clusters origin and dynamical evolution.

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TeV gamma-ray emission initiated by the population or individual millisecond pulsars within globular clusters

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Two energetic millisecond pulsars (MSPs) within globular clusters (GC), J1823-3021A in NGC 6624 and PSR B1821-24 in M28, have been recently discovered to emit pulsed GeV gamma-rays. These MSPs are expected to eject energetic leptons. Therefore, GCs have been proposed to produce GeV-TeV gamma-rays as a result of the comptonization process of the background radiation within a GC. We develop this general scenario by taking into account not only the diffusion process of leptons within a GC but also their advection with the wind from the GC. Moreover, we consider distribution of MSP within a GC and the effects related to the non-central location of the dominating, energetic MSP. Such more complete scenario is considered for the modelling of the GeV-TeV gamma-ray emission from the core collapsed GC M15 and also for GCs which contain recently discovered energetic MSPs within NGC 6624 and M28. The confrontation of the modelling of the gamma-ray emission with the observations with the present Cherenkov telescopes and the future Cherenkov Telescope Array (CTA) allows to constrain more reliably the efficiency of lepton production within the inner magnetosphere of the MSPs and re-accelerated in their vicinity. We discuss the expected limits on this parameter in the context of expectations from the pulsar models. we conclude that deep observations of GCs, even with the present sensitivity of Cherenkov telescopes (H.E.S.S., MAGIC, VERITAS), should start to constrain the models for the acceleration and radiation processes of leptons within the inner pulsar magnetosphere and its surrounding.

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Some remarks on the level of helium enhancement among M3's horizontal-branch stars

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The color and luminosity distribution of horizontal branch (HB) stars in globular clusters (GCs) are sensitive probes of the original helium abundances of those clusters. In this sense, recently the distributions of HB stars in GC color-magnitude diagrams (CMDs) have been extensively used as indicators of possible variations in the helium content Y among the different generations of stars within individual GCs. However, recent analyses based on visual and near-ultraviolet (UV) CMDs have provided conflicting results. To clarify the situation, we address the optimum ranges of applicability (in terms of the Teff range covered by the HB stars) for visual and near-UV CMDs, as far as application of this "HB Y test" goes. We considered both Strömgren and Hubble Space Telescope (HST) bandpasses. In particular, we focus on the F336W filter of the HST, but also discuss several bluer UV bandpasses, such as F160BW, F255W, and F300W. Using the Princeton-Goddard-PUC (PGPUC) code, we computed a large set of zero-age HB (ZAHB) loci and HB evolutionary models for masses ranging from M_{HB}=0.582 to 0.800 $M_{\odot}$, assuming an initial helium abundance Y=0.246, 0.256, and 0.266, with a global metallicity Z=0.001. The results of these calculations were compared against the observations of M3 (NGC 5272), with special attention on the y vs. (b-y) and F336W vs. (F336W-F555W) CMDs. Our results indicate that, from an evolutionary perspective, the distributions of HB stars in the y vs. (b-y) plane can be a reliable indicator of the He content in cool blue HB (BHB) stars, particularly when a differential comparison between blue and red HB stars is carried out in the range $T_{\rm eff}$<8300 K. Conversely, we demonstrate that CMDs using the F336W filter have a much less straightforward interpretation at the cool end of the BHB because the distributions of HB stars in the F336W vs. (F336W-F555W) plane, for instance, are affected by a triple degeneracy effect. In other words, the position of an HB star in such a CMD is exactly the same, for a given chemical composition, for multiple combinations of the parameters Y, MHB, and age along the HB evolutionary track. Other HST UV filters do not appear to be as severely affected by this degeneracy effect, to which visual bandpasses are also immune. On the other hand, such near-UV CMDs can be extremely useful for the hottest stars along the cool BHB end. Based on a reanalysis of the distribution of HB stars in the y vs. (b-y) plane, we find that the coolest BHB stars in M3 (i.e., those with $T_{\rm eff}$<8300 K) are very likely enhanced in helium by $\Delta Y \approx 0.01$, compared with the red HB stars in the same cluster. Using near-UV HST photometry, on the other hand, we find evidence of a progressive increase in Y with increasing temperature, reaching $\Delta Y = 0.02$ at $T_{\rm eff}$ = 10900 K.

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Clusters in the Magellanic clouds

Ages of LMC Star Clusters using $ASAD_2$

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We use $ASAD_2$, the new version of ASAD (Analyzer of Spectra for Age Determination), to obtain the age and reddening of 27 LMC clusters from full fitting of integrated spectra using different statistical methods (χ^2 and K-S test) and a set of stellar population models including GALAXEV and MILES. We show that our results are in good agreement with the CMD ages for both models, and that metallicity does not affect the age determination for the full spectrum fitting method regardless of the model used for ages with log (age/year) < 9. We discuss the results obtained by the two statistical results for both GALAXEV and MILES versus three factors: age, S/N and resolution (FWHM). The predicted reddening values when using the χ^2 minimization method are within the range found in the literature for resolved clusters (i.e: < 0.35), however the K-S test can predict E(BV) higher values. The sharp spectrum transition originated at ages around the supergiants contribution, at either side of the AGB peak around log (age/year) 9.0 and log (age/year) 7.8 are limiting our ability to provide values in agreement with the CMD estimates and as a result the reddening determination is not accurate. We provide the detailed results of four clusters spanning a wide range of ages. $ASAD_2$ is a user-friendly program available for download on the Web and can be immediately used at: `https://randaasad.wordpress.com/reseach-interests/asad-package/`

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The most distant clusters

The Lifecycle of Clusters in Galaxies

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We review many of the basic properties of star cluster systems, and focus in particular on how they relate to their host galaxy properties and ambient environment. The cluster mass and luminosity functions are well approximated by power-laws of the form $Ndm \propto M^{\alpha}dm$, with $\alpha \sim -2$ over most of the observable range. However, there is now clear evidence that both become steeper at high masses/luminosities, with the value of the downward turn dependent on environment. The host galaxy properties also appear to affect the cluster formation efficiency (Γ - i.e., the fraction of stars that form in bound clusters), with higher star- formation rate density galaxies having higher Γ values. Within individual galaxies, there is evidence for Γ to vary by a factor of $3-4$, likely following the molecular gas surface density, in agreement with recent predictions. Finally, we discuss cluster disruption and its effect on the observed properties of a population, focussing on the age distribution of clusters. We briefly discuss the expectations of theoretical and numerical studies, and also the observed distributions in a number of galaxies. Most observational studies now find agreement with theoretical expectations, namely nearly a constant cluster age distribution for ages up to ~ 100 Myr (i.e. little disruption), and a drastic steepening above this value caused by a combination of cluster disruption and incompleteness. Rapid cluster disruption for clusters with ages < 100 Myr is ruled out for most galaxies.

Review chapter to be published in "The Origin of Stellar Clusters", ed. S. Stahler (Springer) `http://arxiv.org/abs/1511.08212`

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A spectral and photometric study of 102 star forming regions in seven spiral galaxies

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We present a study of complexes of young massive star clusters (YMCs), embedded in extragalactic giant H II regions, based on the coupling of spectroscopic with photometric and spectrophotometric observations of about 100 star forming regions in seven spiral galaxies (NGC 628, NGC 783, NGC 2336, NGC 6217, NGC 6946, NGC 7331, and NGC 7678). The complete observational database has been observed and accumulated within the framework of our comprehensive study of extragalactic star forming regions. The current paper presents the last part of either unpublished or refreshed photometric and spectrophotometric observations of the galaxies NGC 6217, NGC 6946, NGC 7331, and NGC 7678. We derive extinctions, chemical abundances, continuum and line emissions of ionised gas, ages and masses for cluster complexes. We find the young massive cluster complexes to have ages no greater than 10 Myr and masses between 10^4 $M_{\odot}$ and 10^7 $M_{\odot}$ and the extinctions A_V vary between ~ 0 and 3 mag, while the impact of the nebular emission on integrated broadband photometry mainly is not greater than 40% of the total flux and is comparable with accuracies of dereddened photometric quantities.We also find evidence of differential extinction of stellar and gas emissions in some clusters, which hinders the photometric determination of ages and masses in these cases. Finally, we show that young massive cluster complexes in the studied galaxies and open clusters in the Milky Way form a continuous sequence of luminosities/masses and colour/ages.

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Is the Escape Velocity in Star Clusters Linked to Extended Star Formation Histories? Using NGC 7252: W3 as a Test Case

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The colour-magnitude diagrams of some intermediate age (1–2 Gyr) star clusters show unexpectedly broad main-sequence turnoffs, raising the possibility that these clusters have experienced more than one episode of star formation. Such a scenario predicts the existence of an extended main sequence turn off (eMSTO) only in clusters with escape velocities above a certain threshold (> 15 km s^{-1}), which would allow them to retain or accrete gas that eventually would fuel a secondary extended star-formation episode. This paper presents a test of this scenario based on the study of the young and massive cluster NGC 7252: W3. We use the *HST* photometry from WFPC2 and WFC3 images obtained with UV and optical filters, as well as MagE echellette spectrograph data from the Las Campanas Clay 6.5m telescope, in order to construct the observed UV/optical SED of NGC 7252: W3. The observations are then compared with synthetic spectra based on different star formation histories consistent with those of the eMSTO clusters. We find that the SED of this cluster is best fitted by a synthetic spectrum with a single stellar population of age 570^{+70}_{-62} Myr and mass $1.13^{+0.14}_{-0.13} \times 10^8$ $M_\odot$, confirming earlier works on NGC 7252:W3. We also estimate the lower limit on the central escape velocity of 193 km s^{-1}. We rule out extended star-formation histories, like those inferred for the eMSTO clusters in the Magellanic Clouds, at high confidence. We conclude that the escape velocity of a cluster does not dictate whether a cluster can undergo extended periods of star formation.

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Globular clusters as the relics of regular star formation in 'normal' high-redshift galaxies

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We present an end-to-end, two-phase model for the origin of globular clusters (GCs). In the model, populations of stellar clusters form in the high-pressure discs of high-redshift ($z > 2$) galaxies (a rapid-disruption phase due to tidal perturbations from the dense interstellar medium), after which the galaxy mergers associated with hierarchical galaxy formation redistribute the surviving, massive clusters into the galaxy haloes, where they remain until the present day (a slow-disruption phase due to tidal evaporation). The high galaxy merger rates of $z > 2$ galaxies allow these clusters to be 'liberated' into the galaxy haloes before they are disrupted within the high-density discs. This physically motivated toy model is the first to include the rapid-disruption phase, which is shown to be essential for simultaneously reproducing the wide variety of properties of observed GC systems, such as their universal characteristic mass-scale, the dependence of the specific frequency on metallicity and galaxy mass, the GC system mass-halo mass relation, the constant number of GCs per unit supermassive black hole mass, and the colour bimodality of GC systems. The model predicts that most of these observables were already in place at $z = 1$–2, although under rare circumstances GCs may still form in present-day galaxies. In addition, the model provides important constraints on models for multiple stellar populations in GCs by putting limits on initial GC masses and the amount of pristine gas accretion. The paper is concluded with a discussion of these and several other predictions and implications, as well as the main open questions in the field.

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`http://adsabs.harvard.edu/abs/2015MNRAS.454.1658K`

Dynamical evolution - Simulations

How can young massive clusters reach their present-day sizes?

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The classic question that how young massive star clusters attain their shapes and sizes, as we find them today, remains to be a challenge. Both observational and computational studies of star-forming massive molecular gas clouds infer that massive cluster formation is primarily triggered along the small-scale (< 0.3 pc) filamentary substructures within the clouds. The present study is intended to investigate the possible ways in which a filament-like-compact, massive star cluster (effective radius 0.1-0.3 pc) can expand > 10 times, still remaining massive enough ($> 10^4\ M_\odot$), to become a young massive star cluster, as we observe today. To that end, model massive clusters (of initially $10^4\ M_\odot$ – $10^5\ M_\odot$) are evolved using Sverre Aarseth's state-of-the-art N-body code NBODY7. All the computed clusters expand with time, whose sizes (effective radii) are compared with those observed for young massive clusters, of age < 100 Myr, in the Milky Way and other nearby galaxies. It is found that beginning from the above compact sizes, a star cluster cannot expand by its own, i.e., due to two-body relaxation, stellar-evolutionary mass loss, dynamical heating by primordial binaries and stellar-mass black holes, up to the observed sizes of young massive clusters; they always remain much more compact compared to the observed ones. This calls for additional mechanisms that can boost the expansion of a massive cluster after its assembly. Using further N-body calculations, it is shown that a substantial residual gas expulsion, with approx. 30% star formation efficiency, can indeed swell the newborn embedded cluster adequately. The limitations of the present calculations and their consequences are discussed.

Accepted by : Astronomy & Astrophysics

`http://arxiv.org/abs/1510.04293`

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Limits on the significant mass-loss scenario based on the globular clusters of the Fornax dwarf spheroidal galaxy

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Many of the scenarios proposed to explain the origin of chemically peculiar stars in globular clusters (GCs) require significant mass-loss ($\geq 95\%$) to explain the observed fraction of such stars. In the GCs of the Fornax dwarf galaxy significant mass-loss could be a problem. Larsen et al. (2012) showed that there is a large ratio of GCs to metal-poor field stars in Fornax and about $20 - 25\%$ of all the stars with [Fe/H] < -2 belong to the four metal-poor GCs. This imposes an upper limit of $\sim 80\%$ mass-loss that could have happened in Fornax GCs. In this paper, we propose a solution to this problem by suggesting that stars can leave the Fornax galaxy. We use a series of N-body simulations, to determine the limit of mass-loss from Fornax as a function of the initial orbital radii of GCs and the speed with which stars leave Fornax GCs. We consider a set of cored and cuspy density profiles for Fornax. Our results show that with a cuspy model for Fornax, the fraction of stars which leave the galaxy, can be as high as $\sim 90\%$, when the initial orbital radii of GCs are $R = 2 - 3\,\mathrm{kpc}$ and the initial speed of stars is $v > 20\,\mathrm{km\,s^{-1}}$. We show that such large velocities can be achieved by gas expulsion induced mass-loss but not stellar evolution induced mass-loss. Our results imply that one cannot interpret the metallicity distribution of Fornax field stars as evidence against significant mass-loss in Fornax GCs, if mass-loss is due to gas expulsion.

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`http://arxiv.org/abs/1512.05260`

The dynamical fate of binary star clusters in the Galactic tidal field

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Fragmentation and fission of giant molecular clouds occasionally results in a pair of gravitationally bound star clusters that orbit their mutual centre of mass for some time, under the influence of internal and external perturbations. We investigate the evolution of binary star clusters with different orbital configurations, with a particular focus on the Galactic tidal field. We carry out N-body simulations of evolving binary star clusters and compare our results with estimates from our semi-analytic model. The latter accounts for mass loss due to stellar evolution and two-body relaxation, and for evolution due to external tides. Using the semi-analytic model we predict the long-term evolution for a wide range of initial conditions. It accurately describes the global evolution of such systems, until the moment when a cluster merger is imminent. N-body simulations are used to test our semi-analytic model and also to study additional features of evolving binary clusters, such as the kinematics of stars, global cluster rotation, evaporation rates, and the cluster merger process. We find that the initial orientation of a binary star cluster with respect to the Galactic field, and also the initial orbital phase, are crucial for its fate. Depending on these properties, the binaries may experience orbital reversal, spiral-in, or vertical oscillation about the Galactic plane before they actually merge at t≈100 Myr, and produce rotating star clusters with slightly higher evaporation rates. The merger process of a binary cluster induces an outburst that ejects ∼10% of the stellar members into the Galactic field.

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`http://arxiv.org/abs/1601.01752`

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The Sizes of Globular Clusters as Tracers of Galactic Halo Potentials

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We present N-body simulations of globular clusters, exploring the effect of different galactic potentials on cluster sizes, r_h. For various galactocentric distances, R_G, we assess how cluster sizes change when we vary the virial mass and concentration of the host galaxy's dark-matter halo. We show that sizes of GCs are determined by the local galactic mass density rather than the virial mass of the host galaxy. We find that clusters evolving in the inner haloes of less concentrated galaxies are significantly more extended than those evolving in more concentrated ones, while the sizes of those orbiting in the outer halo are almost independent of concentration. Adding a baryonic component to our galaxy models does not change these results much, since its effect is only significant in the very inner halo. Our simulations suggest that there is a relation between r_h and R_G, which systematically depends on the physical parameters of the halo. Hence, observing such relations in individual galaxies can put a new observational constraint on dark-matter halo characteristics. However, by varying the halo mass in a wide range of $10^9 \leq M_{vir}/M_\odot \leq 10^{13}$, we find that the $r_h - R_G$ relationship will be nearly independent of halo mass, if one assumes M_{vir} and c_{vir} as two correlated parameters, as is suggested by cosmological simulations.

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`http://adsabs.harvard.edu/abs/2016ApJ...818...58Z`

Formation of Very Young Massive Clusters and implications for globular clusters

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How Very Young Massive star Clusters (VYMCs; also known as "starburst" clusters), which typically are of >10000 $M_\odot$ and are a few Myr old, form out of Giant Molecular Clouds is still largely an open question. Increasingly detailed observations of young star clusters and star-forming molecular clouds and computational studies provide clues about their formation scenarios and the underlying physical processes involved. This chapter is focused on reviewing the decade-long studies that attempt to computationally reproduce the well-observed nearby VYMCs, such as the Orion Nebula Cluster, R136 and NGC 3603 young cluster, thereby shedding light on birth conditions of massive star clusters, in general. On this regard, focus is given on direct N-body modeling of real-sized massive star clusters, with a monolithic structure and undergoing residual gas expulsion, which have consistently reproduced the observed characteristics of several VYMCs and also of young star clusters, in general. The connection of these relatively simplified model calculations with the structural richness of dense molecular clouds and the complexity of hydrodynamic calculations of star cluster formation is presented in detail. Furthermore, the connections of such VYMCs with globular clusters, which are nearly as old as our Universe, is discussed. The chapter is concluded by addressing long-term deeply gas-embedded (at least apparently) and substructured systems like W3 Main. While most of the results are quoted from existing and up-to-date literature, in an integrated fashion, several new insights and discussions are provided.

Review chapter to be published in "The Origin of Stellar Clusters", ed. S. Stahler (Springer) `http://arxiv.org/abs/1512.03074`

Proceedings abstracts

The Imprints Of Galactic Environment On Cluster Formation and Evolution

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Young star clusters (YSCs) appear to be a ubiquitous product of star formation in local galaxies, thus, they can be used to study the star formation process at work in their host galaxies. Moreover, YSCs are intrinsically brighter that single stars, potentially becoming the most important tracers of the recent star formation history in galaxies in the local Universe. In local galaxies, we also witness the presence of a large population of evolved star clusters, commonly called globular clusters (GCs). GCs peak formation history is very close to the redshift (z∼2) when the cosmic star formation history reached the maximum. Therefore, GCs are usually associated to extreme star formation episodes in high-redshift galaxies. It is yet not clear whether YSCs and GCs share a similar formation process (same physics under different interstellar medium conditions) and evolution process, and whether the former can be used as progenitor analogs of the latter. In this invited contribution, I review general properties of YSC populations in local galaxies. I will summarise some of the current open questions in the field, with particular emphasis to whether or not galactic environments, where YSCs form, leave imprints on the nested populations. The importance of this rapidly developing field can be crucial in understanding GC formation and possibly the galactic environment condition where this ancient population formed.

To appear in : The proceedings of IAU symp. 316, "Formation, evolution, and survival of massive star clusters", eds. C. Charbonnel & A. Nota
http://arxiv.org/abs/1511.05567

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On the subject of the Ba overabundance in the open clusters stars

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For eight distant open clusters, namely Ruprecht 4, Ruprecht 7, Berkeley 25, Berkeley 73, Berkeley 75, NGC 6192, NGC 6404, and NGC 6583, we determined the yttrium and barium abundances using the UVES, VLT spectra (ESO, Chile).The stars of one young cluster (Ruprecht 7) demonstrate significant barium overabundance (∼ 0.55 dex) that can not be due to the determination error. We have considered the Ba abundance determination errors due to LTE approach, saturation of the lines, synthetic and observed barium line fitting, and the causes of the Ba overabundance associated with the Galactic disc enrichment or the origin of open clusters. Possible explanation for this overabundance can be the origin of n-capture elements enrichment of the clusters (galactic or extragalactic) or additional sources of the Ba production.

To appear in : Journal of Physics: Conference Series 665 (2016) 012025
http://iopscience.iop.org/1742-6596/665/1/012025

Conferences

COSMIC-LAB: Star Clusters as Cosmic Laboratories for Astrophysics, Dynamics and Fundamental Physics (MODEST 16)

18–22 April, 2016
Bologna, Italy
http://www.cosmic-lab.eu/Cosmic-Lab/The_Conference.html

Registration and abstract submission deadline: Feb. 28, 2016!!!

The Role of Feedback in the Formation and Evolution of Star Clusters

18–22 July, 2016
Sexten, Italy
http://www.sexten-cfa.eu/en/conferences/2016/details/72-the-role-of-feedback-in-the-formation-and-evolution-of-star-clusters.html

Multiple Populations in Stellar Clusters: Where do we stand?

25–29 July, 2016
Sexten, Italy
http://www.sexten-cfa.eu/en/conferences/2016/details/74-6-multiple-populations-in-stellar-clusters-where-do-we-stand.html

Star Clusters: from Infancy to Teenagehood

8–12 August, 2016
Heidelberg, Germany
http://wwwstaff.ari.uni-heidelberg.de/infant_clusters_2016/

Abstract submission deadline: April 3, 2016

Stars on the run - A meeting on run-away and hyper-velocity stars

16–19 August, 2016
Bamberg, Germany
http://www.black-hole.eu/index.php/hvs2016

Announcements

New catalogue of optically visible open clusters and candidates version 3.5 (2016)

W. S. Dias
UNIFEI, Instituto de Física e Química, Universidade Federal de Itajubá, Itajubá MG, Brazil

We are pleased to announce that the most recent version (3.5) of the DAML02 Catalogue is available online at:
`http://www.wilton.unifei.edu.br/ocdb/` and
`http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=B/ocl`

Jobs

Faculty Positions in Astrophysics at Instituto de Astrofisica de Atacama, Copiapo (Chile)

The Instituto de Astrofisica de Atacama (IAA) at the Universidad De Atacama (UDA) in Copiapo (Chile) invites applications for two faculty positions to join the IAA team. The successful candidates will join a group of five faculty working on a broad range of research topics and will have access to the Chilean Time in a broad array of facilities, including ALMA, VLT, Gemini, Magellan, LSST, GMT and the E-ELT. We are particularly interested in candidates with strong experience in one or more of these fields:

- Origin, structure and evolution of planets, satellites, and minor bodies in the Solar System;
- Extrasolar Planets;
- Formation, structure and evolution of stars;
- Milky Way: stellar populations, star clusters, variable stars, galactic structure;
- Terrestrial Mars analogs;
- Astrobiology

The positions carry teaching duties in astronomy at the undergraduate level, with a load of 6h per week. The working language is English. While knowledge of Spanish is not required (teaching can be done in English), the successful candidates are expected to teach in Spanish within two years. The appointment at UDA will be for three years, with a first probation year, and the position is further extendable subject to performance. Applicants should have a PhD in astronomy or physics or related sciences completed at least 3 years prior to the starting day of the contract. To receive full consideration, applications must be sent by Friday 18 of March 2016, although the position will remain open until filled. Start date is expected to be October 2016.

Applications must be submitted by e-mail to Mauro Barbieri (mauro.barbieri@uda.cl)

Further details can be found at: `http://eas.unige.ch/jobs.jsp?id=671`