Dear Colleagues,

It is my pleasure to present you the 139th issue of the Magellanic Clouds Newsletter.

What’s in season? Clearly Cepheids and eclipsing binaries, and Cepheids in eclipsing binaries; O stars, star clusters, supernova remnants and dust production. And more. Enjoy!

Just a gentle reminder that pictures (images, diagrams, cartoons...) for the front cover of the newsletter remain very welcome, and are a great way of advertising your work – contact astro.mcnews@keele.ac.uk if you’ve got one.

The next issue is planned to be distributed on the 1st of April 2016.

Editorially Yours,

Jacco van Loon
We present and describe the astro-photometric catalog of more than 800,000 sources found in the *Hubble Tarantula Treasury Project* (HTTP). HTTP is a *Hubble* Space Telescope (HST) Treasury program designed to image the entire 30 Doradus region down to the sub-solar ($\sim 0.5 M_\odot$) mass regime using the Wide Field Camera 3 (WFC3) and the Advanced Camera for Surveys (ACS). We observed 30 Doradus in the near ultraviolet (F275W, F336W), optical (F555W, F658N, F775W), and near infrared (F110W, F160W) wavelengths. The stellar photometry was measured using point-spread function (PSF) fitting across all the bands simultaneously. The relative astrometric accuracy of the catalog is 0.4 mas. The astro-photometric catalog, results from artificial star experiments and the mosaics for all the filters are available for download. Color–magnitude diagrams are presented showing the spatial distributions and ages of stars within 30 Dor as well as in the surrounding fields. HTTP provides the first rich and statistically significant sample of intermediate and low mass pre-main sequence candidates and allows us to trace how star formation has been developing through the region. The depth and high spatial resolution of our analysis highlight the dual role of stellar feedback in quenching and triggering star formation on the giant H\textsuperscript{\textsc{ii}} region scale. Our results are consistent with stellar sub-clustering in a partially filled gaseous nebula that is offset towards our side of the Large Magellanic Cloud.

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The dust properties and physical conditions of the interstellar medium in the LMC massive star forming complex N 11

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We combine Spitzer and Herschel data of the star-forming region N 11 in the Large Magellanic Cloud to produce detailed maps of the dust properties in the complex and study their variations with the ISM conditions. We also compare APEX/LABOCA 870-\textmu m observations with our model predictions in order to decompose the 870-\textmu m emission into dust and non-dust (free-free emission and CO(3–2) line) contributions. We find that in N 11, the 870-\textmu m emission can be fully accounted for by these 3 components. The dust surface density map of N 11 is combined with H\textsc{I} and CO observations to study local variations in the gas-to-dust mass ratios. Our analysis leads to values lower than those expected from the LMC’s low metallicity as well as to a decrease of the gas-to-dust mass ratio with the dust surface density. We explore potential hypotheses that could explain the low “observed” gas-to-dust mass ratios (variations in the XCO factor, presence of CO-dark gas or of optically thick H\textsc{I} or variations in the dust abundance in the dense regions). We finally decompose the local SEDs using a Principal Component Analysis (i.e. with no a priori assumption on the dust composition in the complex). Our results lead to a promising decomposition of the local SEDs in various dust components (hot, warm, cold) coherent with that expected for the region. Further analysis on a larger sample of galaxies will follow in order to understand how unique this decomposition is or how it evolves from one environment to another.

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Catalogue of Large Magellanic Cloud star clusters observed in the Washington photometric system

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Aims: The main goal of this study is to compile a catalogue of the fundamental parameters of a complete sample of

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277 star clusters (SCs) of the Large Magellanic Cloud (LMC) observed in the Washington photometric system. A set of 82 clusters was recently studied by our team.

Methods: All the clusters' parameters such as radii, deprojected distances, reddenings, ages, and metallicities were obtained by applying essentially the same procedures, which are briefly described here. We used empirical cumulative distribution functions to examine age, metallicity and deprojected distance distributions for different cluster subsamples of the catalogue.

Results: Our new sample of 82 additional clusters represents about a 40% increase in the total number of LMC SCs observed to date in the Washington photometric system. In particular, we report here the fundamental parameters obtained for the first time for 42 of these clusters. We found that single LMC SCs are typically older than multiple SCs. Both single and multiple SCs exhibit asymmetrical distributions in log(age). We compared cluster ages derived through isochrone fittings obtained using different models of the Padova group. Although $t_C$ and $t_B$ ages obtained using isochrones from Girardi et al. (2002) and Bressan et al. (2012), respectively, are consistent in general terms, we found that $t_B$ values are not only typically larger than $t_C$ ages but also that Bressan et al.'s age uncertainties are clearly smaller than the corresponding Girardi et al. values.

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New quasars behind the Magellanic Clouds. Spectroscopic confirmation of near-infrared selected candidates

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Quasi-stellar objects (quasars) located behind nearby galaxies provide an excellent absolute reference system for astrometric studies, but they are difficult to identify because of foreground contamination. Deep wide-field, high angular resolution surveys spanning the entire area of nearby galaxies are needed to obtain a complete census of such quasars. We embarked on a program to expand the quasar reference system behind the Large and Small Magellanic Clouds, the Magellanic Bridge, and the Magellanic Stream, connecting the Clouds with the Milky Way. Hundreds of quasar candidates were selected based on their near-infrared colors and variability properties from the ongoing public ESO VISTA Magellanic Clouds survey. A subset of 49 objects was followed up with optical spectroscopy. We confirmed the quasar nature of 37 objects (34 new identifications), four are low redshift objects, three are probably stars, and the remaining three lack prominent spectral features for a secure classification; bona fide quasars, judging from their broad absorption lines are located, as follows: 10 behind the LMC, 13 behind the SMC, and 14 behind the Bridge. The quasars span a redshift range from $z \sim 0.5$ to $z \sim 4.1$. Upon completion the VMC survey is expected to yield a total of $\sim 1500$ quasars with $Y < 19.32$ mag, $J < 19.09$ mag, and $K_s < 18.04$ mag.

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A systematic study of evolved supernova remnants in the Large and Small Magellanic Clouds with Suzaku

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Typing the origin (i.e. Type Ia or core-collapse) of supernova remnants (SNRs) is crucial to determine the rates of supernova (SN) explosions in a galaxy, which is a key to understand its recent chemical evolution. However, evolved SNRs in the so-called Sedov phase are dominated by the swept-up interstellar medium (ISM), making it difficult to determine their ejecta composition and thus SN type. Here we present a systematic X-ray study of nine evolved SNRs in the Magellanic Clouds, DEM L238, DEM L249, 0534−69.9, 0548−70.4, B 0532−71.0, B 0532−67.5, 0103−72.6, 0049−73.6, and 0104−72.3, using archival data of the Suzaku satellite. Although Suzaku does not spatially resolve the SN ejecta from the swept-up ISM due to the limited angular resolution, its excellent energy resolution has enabled clear separation of emission lines in the soft X-ray band. This leads to the finding that the ‘spatially-integrated’ spectra of the evolved (∼ 10⁴ yr) SNRs are still significantly contributed by emission from the ejecta at the energies around 1 keV. The Fe/Ne mass ratios, determined mainly from the well-resolved Fe L-shell and Ne K-shell lines, clearly divide the observed SNRs into the Type Ia and core-collapse groups, confirming some previous typing made by Chandra observations that had utilized its extremely high angular resolution. This demonstrates that spatially-integrated X-ray spectra of old SNRs can also be used to discriminate their progenitor type, which would be helpful for future systematic studies of extragalactic SNRs with ASTRO-H and beyond.

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Near-infrared polarization source catalog of the north-eastern regions of the Large Magellanic Cloud

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We present a near-infrared band-merged photometric and polarimetric catalog for the 39′ × 69′ fields on the north-eastern part of the Large Magellanic Cloud (LMC), which were observed using SIRPOL, an imaging polarimeter of the InfraRed Survey Facility (IRSF). This catalog lists 1,858 sources brighter than 14 mag at H band with polarization signal-to-noise ratio greater than three in the J, H, or Ks bands. Based on the relationship between the extinction and the polarization degree, we argue that the polarization mostly arises from dichroic extinctions caused by local interstellar dust in the LMC. This catalog allows us to map polarization structures to examine the global geometry of the local magnetic field, and to show a statistical analysis of polarization of each field to understand its polarization properties. At the selected fields with coherent polarization position angles, we estimate magnetic field strengths in the range of 3–25 µG using the Chandrasekhar–Fermi method. This implies the presence of large-scale magnetic fields on a scale of around one hundred parsecs. When comparing mid and far-infrared dust emission maps, we confirmed that the polarization patterns are well aligned with molecular clouds around the star-forming regions.

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The population of classical novæ in the Magellanic Clouds was poorly known because of a lack of systematic studies. There were some suggestions that nova rates per unit mass in the Magellanic Clouds were higher than in any other galaxy. Here, we present an analysis of data collected over sixteen years by the OGLE survey with the aim of characterizing nova population in the Clouds. We found twenty eruptions of novæ, half of them are new discoveries. We robustly measure the nova rates of $2.4 \pm 0.8 \, \text{yr}^{-1}$ (LMC) and $0.9 \pm 0.4 \, \text{yr}^{-1}$ (SMC) and confirm that $K$-band luminosity-specific nova rates in both Clouds are 2–3 times higher than in other galaxies. This can be explained by the star formation history in the Magellanic Clouds, specifically a re-ignition of the star formation rate a few Gyr ago. We also present the discovery of an intriguing system OGLE-MBR 133.25.1160 which mimics recurrent nova eruptions.

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Deuterated polycyclic aromatic hydrocarbons: Revisited

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The amount of deuterium locked up in polycyclic aromatic hydrocarbons (PAHs) has to date been an uncertain value. We present a near-infrared (NIR) spectroscopic survey of H II regions in the Milky Way, Large Magellanic Cloud (LMC), and Small Magellanic Cloud (SMC) obtained with AKARI, which aims to search for features indicative of deuterated PAHs (P AD or Dn-P AH) to better constrain the D/H ratio of PAHs. Fifty-three H II regions were observed in the NIR (2.5–5 μm), using the Infrared Camera (IRC) on board the AKARI satellite. Through comparison of the observed spectra with a theoretical model of deuterated PAH vibrational modes, the aromatic and (a)symmetric aliphatic C–D stretch modes were identified. We see emission features between 4.4–4.8 μm, which could be unambiguously attributed to deuterated PAHs in only six of the observed sources, all of which are located in the Milky Way. In all cases, the aromatic C–D stretching feature is weaker than the aliphatic C–D stretching feature, and, in the case of M 17b, this feature is not observed at all. Based on the weak or absent PAD features in most of the observed spectra, it is suggested that the mechanism for PAH deuteration in the ISM is uncommon.

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Apsidal motion and a light curve solution for 13 LMC eccentric eclipsing binaries

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New CCD observations for 13 eccentric eclipsing binaries from the Large Magellanic Cloud were carried out using the Danish 1.54 m telescope located at the La Silla Observatory in Chile. These systems were observed for their times of minimum and 56 new minima were obtained. These are needed for accurate determination of the apsidal motion. Besides that, in total 436 times of minimum were derived from the photometric databases OGLE and MACHO. The
O–C diagrams of minimum timings for these B-type binaries were analyzed and the parameters of the apsidal motion were computed. The light curves of these systems were fitted using the program PHOEBE, giving the light curve parameters. We derived for the first time relatively short periods of the apsidal motion ranging from 21 to 107 years. The system OGLE-LMC-ECL-07902 was also analyzed using the spectra and radial velocities, resulting in masses of 6.8 and 4.4 $M_\odot$ for the eclipsing components. For one system (OGLE-LMC-ECL-20112), the third-body hypothesis was also used to describe the residuals after subtraction of the apsidal motion, resulting in a period of about 22 years. For several systems an additional third light was also detected, which makes these systems suspect for triplicity. Based on data collected with the Danish 1.54 m telescope at the ESO La Silla Observatory.

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On the eclipsing binary ELHC 10 with occulting dark disc in the Large Magellanic Cloud

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We investigate the luminous star ELHC 10 located in the bar of the Large Magellanic Cloud, concluding that it is a SB1 long-period eclipsing binary where the main eclipse is produced by an opaque structure hiding the secondary star. For the more luminous component we determine an effective temperature of 6500 ± 250 K, log $g$ = 1.0 ± 0.5 and luminosity 5970 $L_\odot$. From the radial velocities of their photospheric lines we calculate a mass function of 7.37 ± 0.55 $M_\odot$. Besides Balmer and forbidden N II emission, we find splitting of metallic lines, characterized by strong discrete absorption components (DACs), alternatively seen at the blue and red side of the photospheric spectrum. These observations hardly can be interpreted in terms of an structured atmosphere but might reflect mass streams in an interacting binary. The primary shows signatures of s-process nucleosynthesis and might be a low-mass post-AGB star with a rare evolutionary past if the binary is semi-detached. The peak separation and constancy of radial velocity in Hα suggest that most of the Balmer emission comes from a circumbinary disc.

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The OGLE collection of variable stars. Classical Cepheids in the Magellanic System

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We present here a nearly complete census of classical Cepheids in the Magellanic System. The sample extends the set of Cepheids published in the past by the Optical Gravitational Lensing Experiment (OGLE) to the outer regions of
the Large (LMC) and Small Magellanic Cloud (SMC). The entire collection consists of 9535 Cepheids of which 4620 belong to the LMC and 4915 are members of the SMC. We provide the $I$- and $V$-band time-series photometry of the published Cepheids, their finding charts, and basic observational parameters.

Based on this unique OGLE sample of Cepheids we present updated period–luminosity relations for fundamental, first, and second mode of pulsations in the $I$- and $V$-bands and for the WI extinction-free Wesenheit index. We also show the distribution of classical Cepheids in the Magellanic System.

The OGLE collection contains several classical Cepheids in the Magellanic Bridge – the region of interaction between the Magellanic Clouds. The discovery of classical Cepheids and their estimated ages confirm the presence of young stellar population between these galaxies.

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**Multi-mode and non-standard classical Cepheids in the Magellanic System**


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We present a sample of the most interesting classical Cepheids selected from the OGLE collection of classical Cepheids in the Magellanic System. The main selection criterion for this sample was the presence of non-standard, unique pulsational properties.

The sample contains the first known double-mode Cepheid pulsating in the second- and third-overtone modes and a large number of objects with non-radial modes excited. We also found Cepheids revealing Blazhko-like light curve modulation, objects ceasing pulsations or showing atypical shapes of their light curves. Additionally, the status of several triple mode classical Cepheids is updated based on OGLE-IV photometry extending the time baseline to 15 years.

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**On the nature of the most obscured C-rich AGB stars in the Magellanic Clouds**

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The stars in the Magellanic Clouds with the largest degree of obscuration are used to probe the highly uncertain physics of stars in the asymptotic giant branch (AGB) phase of evolution. Carbon stars in particular, provide key information on the amount of third dredge-up (TDU) and mass loss. We use two independent stellar evolution codes to test how a different treatment of the physics affects the evolution on the AGB. The output from the two codes are used to determine the rates of dust formation in the circumstellar envelope, where the method used to determine the
dust is the same for each case. The stars with the largest degree of obscuration in the LMC and SMC are identified as the progeny of objects of initial mass 2.5–3 $M_\odot$ and $\sim$ 1.5 $M_\odot$, respectively. This difference in mass is motivated by the difference in the star formation histories of the two galaxies, and offers a simple explanation of the redder infrared colours of C-stars in the LMC compared to their counterparts in the SMC. The comparison with the Spitzer colours of C-rich AGB stars in the SMC shows that a minimum surface carbon mass fraction $X(C) \sim 5 \times 10^{-3}$ must have been reached by stars of initial mass around 1.5 $M_\odot$. Our results confirm the necessity of adopting low-temperature opacities in stellar evolutionary models of AGB stars. These opacities allow the stars to obtain mass-loss rates high enough ($\gtrsim 10^{-4} M_\odot \text{yr}^{-1}$) to produce the amount of dust needed to reproduce the Spitzer colours.

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Classical Oe stars in the field of the Small Magellanic Cloud

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We present $29 \pm 1$ classical Oe stars from RIOTS4, a spatially complete, spectroscopic survey of Small Magellanic Cloud (SMC) field OB stars. The two earliest are O6e stars, and four are earlier than any Milky Way (MW) Oe stars. We also find ten Ope stars, showing He i infill and/or emission; five appear to be at least as hot as $\sim$O7.5e stars. The hottest, star 77616, shows He ii disk emission, suggesting that even the hottest O stars can form decretion disks, and offers observational support for theoretical predictions that the hottest, fastest rotators can generate He$^+$-ionizing atmospheres. Our data also demonstrate that Ope stars correspond to Oe stars earlier than O7.5e with strong disk emission. We find that in the SMC, Oe stars extend to earlier spectral types than in the MW, and our SMC Oe/O frequency, $0.26 \pm 0.04$, is much greater than the MW value, $0.03 \pm 0.01$. These results are consistent with angular momentum transport by stronger winds suppressing decretion disk formation at higher metallicity. In addition, our SMC field Oe star frequency is indistinguishable from that for clusters, which is consistent with the similarity between rotation rates in these environments, and contrary to the pattern for MW rotation rates. Thus, our findings strongly support the viscous decretion disk model and confirm that Oe stars are the high-mass extension of the Be phenomenon. Additionally, we find that Fe ii emission occurs among Oe stars later than O7.5e with massive disks, and we revise a photometric criterion for identifying Oe stars to $J - [3.6] \geq 0.1$ mag.

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Infrared continuum and line evolution of the equatorial ring around SN 1987A

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Spitzer observations of SN 1987A have now spanned more than a decade. Since day $\sim 4,000$, mid-infrared (mid-IR) emission has been dominated by that from shock-heated dust in the equatorial ring (ER). From 6,000 to 8,000
days after the explosion, Spitzer observations included broadband photometry at 3.6–24 µm, and low and moderate resolution spectroscopy at 5–35 µm. Here we present later Spitzer observations, through day 10,377, which include only the broadband measurements at 3.6 and 4.5 µm. These data show that the 3.6 and 4.5 µm brightness has clearly begun to fade after day $\sim 8,500$, and no longer tracks the X-ray emission as well as it did at earlier epochs. This can be explained by the destruction of the dust in the ER on time scales shorter than the cooling time for the shocked gas. We find that the evolution of the late time IR emission is also similar to the now fading optical emission. We provide the complete record of the IR emission lines, as seen by Spitzer prior to day 8,000. The past evolution of the gas as seen by the IR emission lines seems largely consistent with the optical emission, although the IR [Fe ii] and [Si ii] lines show different, peculiar velocity structures.

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Pan-chromatic observations of the recurrent nova LMC 2009a (LMC 1971b)


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Nova LMC 2009a is confirmed as a Recurrent Nova (RN) from positional coincidence with nova LMC 1971b. The observational data set is one of the most comprehensive for any Galactic or extragalactic RN: optical and near-IR photometry from outburst until over 6 years later; optical spectra for the first 6 months, and Swift satellite Ultraviolet and X-ray observations from 9 days to almost 1 year post-outburst. We find $M_V = -8.4 \pm 0.8$, $i = 0.7$, and expansion velocities between 1000 and 4000 km s$^{-1}$. Coronal line emission before day 9 indicates shocks in the ejecta. Strengthening of He ii $\lambda 4686$ preceded the emergence of the Super-Soft Source (SSS) in X-rays at $\sim 63–70$ days, which was initially very variable. Periodic modulations, $P = 1.2$ days, most probably orbital in nature, were evident in the UV and optical from day 43. Subsequently, the SSS shows an oscillation with the same period but with a delay of 0.28$P$. The progenitor system has been identified; the secondary is most likely a sub-giant feeding a luminous accretion disk. Properties of the SSS infer a white dwarf (WD) mass $1.1 \, M_\odot \lesssim M(\text{WD}) \lesssim 1.3 \, M_\odot$. If the accretion occurs at constant rate, $\dot{M}_{\text{acc}} = 3.6 \times 10^{-7} \, M_\odot \, \text{yr}^{-1}$ is needed, consistent with nova models for an inter-eruption interval of 38 years, low outburst amplitude, progenitor position in the color–magnitude diagram, and spectral energy distribution at quiescence. We note striking similarities between LMC 2009a and the Galactic nova KT Eri, suggesting that KT Eri is a candidate RN.

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Eclipsing binaries with classical Cepheid component in the Magellanic System

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We present a census of eclipsing binary systems with classical Cepheid as a component. All such systems known were found in the OGLE collection of classical Cepheids in the Magellanic System. We extend the list of potential candidates adding four new objects found in the OGLE-IV photometric data. One of the new Cepheids in the eclipsing system, OGLE-SMC-CEP-3235, revealed only one eclipse during 15 years of the OGLE photometric monitoring. However, it additionally shows very well pronounced light-time effect indicating that the binarity is real and the system is physically bound. We also search for the light-time effect in other known eclipsing Cepheids and we clearly detect it in OGLE-LMC-CEP-1812. We discuss application of this tool for the search for Cepheids in non-eclipsing binary systems.

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The evolved-star dust budget of the Small Magellanic Cloud: the critical role of a few key players

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The lifecycle of dust in the interstellar medium (ISM) is heavily influenced by outflows from asymptotic giant branch (AGB) and red supergiant (RSG) stars, a large fraction of which is contributed by a few very dusty sources. We compute the dust input to the Small Magellanic Cloud (SMC) by fitting the multi-epoch mid-infrared spectral energy distributions (SEDs) of AGB/RSG candidates with models from the Grid of RSG and AGB ModelS (GRAMS) grid, allowing us to estimate the luminosities and dust-production rates (DPRs) of the entire population. By removing contaminants, we guarantee a high-quality dataset with reliable DPRs and a complete inventory of the dustiest sources. We find a global AGB/RSG dust-injection rate of \((1.3 \pm 0.1) \times 10^{-6} \, M_{\odot} \, yr^{-1}\), in agreement with estimates derived from mid-infrared colours and excess fluxes. As in the LMC, a majority (66%) of the dust arises from the extreme AGB stars, which comprise only \(\approx 7\%\) of our sample. A handful of far-infrared sources, whose 24-\(\mu\)m fluxes exceed their 8-\(\mu\)m fluxes, dominate the dust input. Their inclusion boosts the global DPR by \(\approx 1.5\times\), making it necessary to determine whether they are AGB stars. Model assumptions, rather than missing data, are the major sources of uncertainty; depending on the choice of dust shell expansion speed and dust optical constants, the global DPR can be up to \(\approx 10\) times higher. Our results suggest a non-stellar origin for the SMC dust, barring as yet undiscovered evolved stars with very high DPRs.

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The Runaways and Isolated O-Type Star Spectroscopic Survey of the SMC (RIOTS4)

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We present the Runaways and Isolated O-Type Star Spectroscopic Survey of the SMC (RIOTS4), a spatially complete survey of uniformly selected field OB stars that covers the entire star-forming body of the SMC. Using the IMACS multislit spectrograph and MIKE echelle spectrograph on the Magellan telescopes, we obtained spectra of 374 early-type field stars that are at least 28 pc from any other OB candidates. We also obtained spectra of an additional 23 field stars in the SMC bar identified from slightly different photometric criteria. Here, we present the observational catalog of stars in the RIOTS4 survey, including spectral classifications and radial velocities. For three multi-slit fields covering 8% of our sample, we carried out monitoring observations over 9–16 epochs to study binarity, finding a spectroscopic, massive binary frequency of at least \( \sim 60\% \) in this subsample. Classical Oe/Be stars represent a large fraction of RIOTS4 (42%), occurring at much higher frequency than in the Galaxy, consistent with expectation at low metallicity. RIOTS4 confirmed a steep upper IMF in the field, apparently caused by the inability of the most massive stars to form in the smallest clusters. Our survey also yields evidence for in-situ field OB star formation, and properties of field emission-line star populations, including sgB[e] stars and classical Oe/Be stars. We also discuss the radial velocity distribution and its relation to SMC kinematics and runaway stars. RIOTS4 presents a first quantitative characterization of field OB stars in an external galaxy, including the contributions of sparse, but normal, star formation; runaway stars; and candidate isolated star formation.

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VLT/ISAAC infrared spectroscopy of embedded high-mass YSOs in the Large Magellanic Cloud: Methanol and the 3.47-\( \mu \)m band

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This study aims to elucidate a possible link between chemical properties of ices in star-forming regions and environmental characteristics (particularly metallicity) of the host galaxy. The Large Magellanic Cloud (LMC) is an excellent target to study properties of interstellar and circumstellar medium in a different galactic environment thanks to its proximity and low metallicity.

We performed near-infrared, \( L \)-band spectroscopic observations toward embedded high-mass young stellar objects (YSOs) in the LMC with the Infrared Spectrometer And Array Camera (ISAAC) at the Very Large Telescope. The 3.2–3.7-\( \mu \)m spectral region, which is accessible from ground-based telescopes, is important for ice studies, since various C–H stretching vibrations of carbon bearing species fall in this region.

We obtained medium-resolution (\( R \sim 500 \)) spectra in the 3–4-\( \mu \)m range for nine high-mass YSOs in the LMC. Additionally, we analyzed archival ISAAC data of two LMC YSOs. We detected absorption bands due to solid \( \text{H}_2\text{O} \) and \( \text{CH}_3\text{OH} \) as well as the 3.47-\( \mu \)m absorption band. The properties of these bands are investigated based on comparisons.
with Galactic embedded sources. The 3.53-μm CH$_3$OH ice absorption band for the LMC YSOs is found to be absent or very weak compared to that seen toward Galactic sources. The absorption band is weakly detected for two out of eleven objects. We estimate the abundance of the CH$_3$OH ice, which suggests that solid CH$_3$OH is less abundant for high-mass YSOs in the LMC than those in our Galaxy. The 3.47-μm absorption band is detected toward six out of eleven LMC YSOs. We found that the 3.47-μm band and the H$_2$O ice band correlate similarly between the LMC and Galactic samples, but the LMC sources seem to require a slightly higher H$_2$O ice threshold for the appearance of the 3.47-μm band. For the LMC sources with relatively large H$_2$O ice optical depths, we found that the strength ratio of the 3.47-μm band relative to the water ice band is only marginally lower than those of the Galactic sources. We propose that grain surface reactions at a relatively high dust temperature (warm ice chemistry) are responsible for the observed characteristics of ice chemical compositions in the LMC; i.e. the low abundance of solid CH$_3$OH presented in this work as well as the high abundance of solid CO$_2$ reported in previous studies. We suggest that this warm ice chemistry is one of the important characteristics of interstellar and circumstellar chemistry in low metallicity environments. The low abundance of CH$_3$OH in the solid phase implies that formation of complex organic molecules from methanol-derived species is less efficient in the LMC. For the 3.47-μm band, the observed difference in the water ice threshold may suggest that a more shielded environment is necessary for the formation of the 3.47-μm band carrier in the LMC. On the one hand, in well-shielded regions of the LMC, our results suggest that the lower metallicity and different interstellar environment of the LMC have little effect on the abundance ratio of the 3.47-μm band carrier and water ice.

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Embedded clusters in the Large Magellanic Cloud using the VISTA Magellanic Clouds survey
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We present initial results of the first large scale survey of embedded star clusters in molecular clouds in the Large Magellanic Cloud (LMC) using near-infrared (NIR) imaging from the VISTA Magellanic Clouds survey (Cioni et al. 2011). We have explored a $\sim$1.65 square degree area of the LMC, which contains the well-known star-forming region 30 Doradus as well as $\sim$14 per cent of the galaxy’s CO clouds (Wong et al. 2011), and have identified 67 embedded cluster candidates, 45 of which are newly discovered as clusters. We have determined sizes, luminosities and masses for these embedded clusters, examined the star formation rates (SFRs) of their corresponding molecular clouds, and made a comparison between the LMC and the Milky Way. Our preliminary results indicate that embedded clusters in the LMC are generally larger, more luminous and more massive than those in the local Milky Way. We also find that the surface densities of both embedded clusters and molecular clouds is $\sim$3 times higher than in our local environment, the embedded cluster mass surface density is $\sim$40 times higher, the SFR is $\sim$20 times higher, and the star formation efficiency is $\sim$10 times higher. Despite these differences, the SFRs of the LMC molecular clouds are consistent with the SFR scaling law presented in Lada et al. (2012). This consistency indicates that while the conditions of embedded cluster formation may vary between environments, the overall process within molecular clouds may be universal.

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The Cepheids of NGC 1866: A precise benchmark for the extragalactic distance scale and stellar evolution from modern $UBVI$ photometry

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We present the analysis of multiband time-series data for a sample of 24 Cepheids in the field of the Large Magellanic Cloud cluster NGC 1866. Very accurate $BV$ $VLT$ photometry is combined with archival $UBVI$ data, covering a large temporal window, to obtain precise mean magnitudes and periods with typical errors of 1–2% and of 1 ppm, respectively. These results represent the first accurate and homogeneous dataset for a substantial sample of Cepheid variables belonging to a cluster and hence sharing common distance, age and original chemical composition. Comparisons of the resulting multiband Period–Luminosity and Wesenheit relations to both empirical and theoretical results for the Large Magellanic Cloud are presented and discussed to derive the distance of the cluster and to constrain the mass-luminosity relation of the Cepheids. The adopted theoretical scenario is also tested by comparison with independent calibrations of the Cepheid Wesenheit zero point based on trigonometric parallaxes and Baade–Wesselink techniques. Our analysis suggests that a mild overshooting and/or a moderate mass loss can affect intermediate-mass stellar evolution in this cluster and gives a distance modulus of $18.50 \pm 0.01$ mag. The obtained $V, I$ color–magnitude diagram is also analysed and compared with both synthetic models and theoretical isochrones for a range of ages and metallicities and for different efficiencies of core overshooting. As a result, we find that the age of NGC 1866 is about 140 Myr, assuming $Z = 0.008$ and the mild efficiency of overshooting suggested by the comparison with the pulsation models.

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Formation of new stellar populations from gas accreted by massive young star clusters

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Stars in star clusters are thought to form in a single burst from a common progenitor cloud of molecular gas. However, massive, old globular clusters – with ages greater than 10 billion years and masses of several hundred thousand solar masses – often harbour multiple stellar populations, indicating that more than one starforming event occurred during their lifetimes. Colliding stellar winds from late-stage, asymptotic-giant-branch stars are often invoked as second-generation star-formation trigger. The initial cluster masses should be at least 10 times more massive than they are today for this to work. However, large populations of clusters with masses greater than a few million solar masses are not found in the local Universe. Here we report on three 1–2 billion-year-old, massive star clusters in the Magellanic Clouds, which show clear evidence of burst-like star formation that occurred a few hundred million years after their
initial formation era. We show that such clusters could accrete sufficient gas reservoirs to form new stars if the clusters orbited in their host galaxies gaseous discs throughout the period between their initial formation and the more recent bursts of star formation. This may eventually give rise to the ubiquitous multiple stellar populations in globular clusters.

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Conference Papers

Dust and molecules in extra-galactic planetary nebulae

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Extra-galactic planetary nebulae (PNe) permit the study of dust and molecules in metallicity environments other than the Galaxy. Their known distances lower the number of free parameters in the observations vs. models comparison, providing strong constraints on the gas-phase and solid-state astrochemistry models. Observations of PNe in the Galaxy and other Local Group galaxies such as the Magellanic Clouds (MC) provide evidence that metallicity affects the production of dust as well as the formation of complex organic molecules and inorganic solid-state compounds in their circumstellar envelopes. In particular, the lower metallicity MC environments seem to be less favorable to dust production and the frequency of carbonaceous dust features and complex fullerene molecules is generally higher with decreasing metallicity. Here, I present an observational review of the dust and molecular content in extra-galactic PNe as compared to their higher metallicity Galactic counterparts. A special attention is given to the level of dust processing and the formation of complex organic molecules (e.g., polycyclic aromatic hydrocarbons, fullerenes, and graphene precursors) depending on metallicity.

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The orbits and total mass of the Magellanic Clouds

Gurtina Besla

This proceeding overviews our current understanding of the orbital history and mass of the Large and Small Magellanic Clouds. Specifically I will argue that the Clouds are on their first infall about our Milky Way and that their total masses are necessarily ~ 10 times larger than traditionally estimated. This conclusion is based on the recently revised HST proper motions of the Clouds and arguments concerning the binary status of the LMC–SMC pair and their baryon fractions.

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