Dear Colleagues,

It is my pleasure to present you the 137th issue of the Magellanic Clouds Newsletter.

Please note the announcement of a conference on supernova remnants, in Greece next year.

A reminder that pictures for the frontpage of the newsletter are very welcome – just e-mail astro.mcnews@keele.ac.uk.

Looking forward to the “Feedback in the Magellanic Clouds” meeting in Baltimore in a few days time!

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

Editorially Yours,

Jacco van Loon
An X-Shooter view of the symbiotic star [JD2002] 11
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We aimed to verify the nature and derive the basic parameters of the symbiotic star candidate [JD2002] 11. For this purpose, we obtained and analysed an X-Shooter spectrum of [JD2002] 11. We also used optical and infrared photometry available for the object. Emission-line diagnostic ratios are characteristic of a dusty type symbiotic star and reveal a two-component nebula (low- and high-density). The spectral energy distribution is well fitted with a two-component blackbody spectrum with the respective temperatures of 1150 K and 600 K. The total luminosity of 3000 L⊙ is consistent with the expected luminosity of a typical Mira star, embedded in an optically thick dust shell. We conclude that [JD2002] 11 is the ninth symbiotic star in total and only the second dusty type symbiotic star discovered in the Small Magellanic Cloud.

Published in Acta Astronomica, 65, 139 (2015)

The Magellanic Inter-Cloud Project (MAGIC) II: Slicing up the Bridge
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The origin of the gas in between the Magellanic Clouds (MCs), known as the Magellanic Bridge, has always been the subject of controversy. To shed light into this, we present the results from the MAGellanic Inter-Cloud II (MAGIC II) project aimed at probing the stellar populations in 10 large fields located perpendicular to the main ridge-line of H i in the Inter-Cloud region. We secured these observations of the stellar populations in between the MCs using the WFI (Wide Field Imager) camera on the 2.2 m telescope in La Silla. Using colour–magnitude diagrams, we trace stellar populations across the Inter-Cloud region. In good agreement with MAGIC I, we find significant intermediate-age stars in the Inter-Cloud region as well as young stars of a similar age to the last pericentre passage in between the MCs (∼ 200 Myr ago). We show here that the young, intermediate-age and old stars have distinct spatial distributions. The young stars correlate well with the H i gas suggesting that they were either recently stripped from the Small Magellanic Cloud (SMC) or formed in situ. The bulk of intermediate-age stars are located mainly in the bridge region where the H i column density is higher, but they are more spread out than the young stars. They have very similar properties to stars located ∼ 2 kpc from the SMC centre, suggesting that they were tidally stripped from this region. Finally, the old stars extend to some 8 kpc from the SMC supporting the idea that all galaxies have a large extended metal-poor stellar halo.

Accepted for publication in MNRAS
Available from arXiv:1507.05626
Non-Gaussian error distributions of LMC distance moduli measurements

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We construct error distributions for a compilation of 232 Large Magellanic Cloud (LMC) distance moduli values from de Grijs et al. (2014) that give an LMC distance modulus of \((m - M)_0 = 18.49 \pm 0.13\) (median and 1 \(\sigma\) symmetrized error). Central estimates found from weighted mean and median statistics are used to construct the error distributions. The weighted mean error distribution is non-Gaussian – flatter and broader than Gaussian – with more (less) probability in the tails (center) than is predicted by a Gaussian distribution; this could be the consequence of unaccounted-for systematic uncertainties. The median statistics error distribution, which does not make use of the individual measurement errors, is also non-Gaussian – more peaked than Gaussian – with less (more) probability in the tails (center) than is predicted by a Gaussian distribution; this could be the consequence of publication bias and/or the non-independence of the measurements.

Submitted to The Astrophysical Journal
Available from arXiv:1507.07940

Chemical abundance study of two strongly s-process enriched post-AGB stars in the LMC: J051213.81–693537.1 and J051848.86–700246.9

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Context: This paper is part of a larger project in which we systematically study the chemical abundances of extragalactic post-asymptotic giant branch (post-AGB) stars. The aim of our programme is to derive chemical abundances of stars covering a large range in luminosity and metallicity with the ultimate goal of testing, constraining and improving our knowledge of the poorly understood AGB phase, especially the third dredge-up mixing processes and associated s-process nucleosynthesis.

Aims: Post-AGB photospheres are dominated by atomic lines and indicate the effects of internal chemical enrichment processes over the entire stellar lifetime. In this paper, we study two carefully selected post-AGB stars: J051213.81–693537.1 and J051848.86–700246.9 in the Large Magellanic Cloud (LMC). Both objects show signs of s-process enhancement. The combination of favourable atmospheric parameters for detailed abundance studies and their known distances (and hence luminosities and initial masses) make these objects ideal probes of the AGB third dredge-up and s-process nucleosynthesis in that they provide observational constraints for theoretical AGB models.

Methods: We use high-resolution optical UVES spectra to determine accurate stellar parameters and subsequently perform detailed elemental abundance studies of post-AGB stars. Additionally, we use available photometric data covering optical and IR bands to construct spectral energy distributions for reddening and luminosity determinations. We then estimate initial masses from the theoretical post-AGB tracks.

Results: We obtained accurate atmospheric parameters for J051213.81–693537.1 (\(T_{\text{eff}} = 5875 \pm 125\) K, \(\log g = 1.00 \pm 0.25\) dex, [Fe/H] = −0.56 ± 0.16 dex) and J051848.86–700246.9 (\(T_{\text{eff}} = 6000 \pm 125\) K, \(\log g = 0.50 \pm 0.25\) dex, [Fe/H] = −1.06 ± 0.17 dex). Both stars show extreme s-process enrichment associated with relatively low C/O ratios of 1.26 ± 0.40 and 1.29 ± 0.30 for J051213–693537.1 and J051848–700246.9, respectively. We could only derive upper limits of the lead (Pb) abundance. These upper limits show a possible very slight Pb overabundance with respect to heavy s-elements for J051213–693537.1, while J051848–700246.9 shows an upper limit of the Pb abundance similar to [As/Fe]. A comparison with theoretical post-AGB evolutionary tracks in the HR diagram reveals that both stars have low initial masses between 1.0 and 1.5 \(M_\odot\).

Conclusion: This study adds to the results obtained so far on a very limited number of s-process enriched stars in the Magellanic Clouds. With the addition of the two stars in this study, we find an increasing discrepancy between observed and predicted Pb abundances towards lower metallicities of the studied s-process rich post-AGB stars in the Magellanic Clouds. The more metal-rich J051213–693537.1 fits the theoretical Pb abundance predictions well, while the five other objects with [Fe/H] < 1, including J051848–700246.9, have much lower Pb over-abundances than predicted. In all objects found so far, including the objects in this study, the C/O ratio is very moderate because of...
the enhancement of O as well as C. We find that all s-process rich stars in the LMC and SMC studied so far, cluster in the same region of the HR diagram and are associated with low-mass stars with a low metallicity on average. We corroborate the published lack of correlation between the metallicity and the neutron irradiation, while the neutron exposure ([hs/ls]) is strongly correlated with the third dredge-up efficiency ([s/Fe]). These correlations seem to hold in our Galaxy as well as in the Magellanic Clouds.

Accepted for publication in Astronomy and Astrophysics
Available from arXiv:1508.01091

Broad Balmer wings in BA hyper/supergiants distorted by diffuse interstellar bands: five examples in the 30 Doradus region from the VLT-FLAMES Tarantula Survey

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Extremely broad emission wings at Hβ and Hα have been found in VFTS data for five very luminous BA supergiants in or near 30 Doradus in the Large Magellanic Cloud. The profiles of both lines are extremely asymmetrical, which we have found to be caused by very broad diffuse interstellar bands (DIBs) in the longward wing of Hβ and the shortward wing of Hα. These DIBs are well known to interstellar but not to many stellar specialists, so that the asymmetries may be mistaken for intrinsic features. The broad emission wings are generally ascribed to electron scattering, although we note difficulties for that interpretation in some objects. Such profiles are known in some Galactic hyper/supergiants and are also seen in both active and quiescent Luminous Blue Variables. No prior or current LBV activity is known in these 30 Dor stars, although a generic relationship to LBVs is not excluded; subject to further observational and theoretical investigation, it is possible that these very luminous supergiants are approaching the LBV stage for the first time. Their locations in the HRD and presumed evolutionary tracks are consistent with that possibility. The available evidence for spectroscopic variations of these objects is reviewed, while recent photometric monitoring does not reveal variability. A search for circumstellar nebulæ has been conducted, with an indeterminate result for one of them.

Accepted for publication in The Astrophysical Journal
Available from arXiv:1508.03021

2dF-AAΩ spectroscopy of massive stars in the Magellanic Clouds: The north-eastern region of the Large Magellanic Cloud

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We present spectral classifications from optical spectroscopy of 263 massive stars in the north-eastern region of the
Large Magellanic Cloud. The observed two-degree field includes the massive 30 Doradus star-forming region, the environs of SN 1987A, and a number of star-forming complexes to the south of 30 Dor. These are the first classifications for the majority (203) of the stars and include eleven double-lined spectroscopic binaries. The sample also includes the first examples of early OC-type spectra (AAΩ 30 Dor 248 and 280), distinguished by the weakness of their nitrogen spectra and by CIV λ4658 emission. We propose that these stars have relatively unprocessed CNO abundances compared to morphologically normal O-type stars, indicative of an earlier evolutionary phase. From analysis of observations obtained on two consecutive nights, we present radial-velocity estimates for 233 stars, finding one apparent single-lined binary and nine (> 3σ) outliers compared to the systemic velocity; the latter objects could be runaway stars or large-amplitude binary systems and further spectroscopy is required to investigate their nature.

Accepted for publication in A&A

Available from arXiv:1508.03490

Ram pressure stripping of the Large Magellanic Cloud’s disk as a probe of the Milky Way’s circumgalactic medium

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Recent observations have constrained the orbit and structure of the Large Magellanic Cloud (LMC), implying a well-constrained pericentric passage about the Milky Way (MW) ∼ 50 Myr ago. In this scenario, the LMC’s gaseous disk has recently experienced stripping, suggesting the current extent of its H I disk directly probes the medium in which it is moving. From the observed stellar and H I distributions of the system we find evidence of a truncated gas profile along the windward “leading edge” of the LMC disk, despite a far more extended stellar component. We explore the implications of this ram pressure stripping signature, using both analytic prescriptions and full 3-dimensional hydrodynamic simulations of the LMC. Our simulations subject the system to a headwind whose velocity components correspond directly to the recent orbital history of the LMC. We vary the density of this headwind, using a variety of sampled parameters for a β-profile for a theoretical MW circumgalactic medium (CGM), comparing the resulting H I morphology directly to observations of the LMC H I and stellar components. This model can match the radial extent of the LMC’s leading (windward) edge only in scenarios where the MW CGM density at pericentric passage is \( n_p(R = 48.2 \pm 5 \text{ kpc}) = 1.1^{+1.4}_{-0.5} \times 10^{-4} \text{ cm}^{-3} \). The implied pericentric density proves insensitive to both the broader CGM structure and temperature profile, thus providing a model-independent constraint on the local gas density. This result imposes an important constraint on the density profile of the MW’s CGM, and thus the total baryon content of the MW. From our work, assuming a β-profile valid to ∼ \( r_{\text{vir}} \), we infer a total diffuse CGM mass \( M(300 \text{ kpc}) = 2.6 \pm 1.4 \times 10^{10} \text{ M}_\odot \) or approximately 15% of a \( 10^{12} \text{ M}_\odot \) MW’s baryonic mass budget.

Submitted to ApJ

Available from arXiv:1507.07935
and from https://lavinia.as.arizona.edu/~gbesla/MWHotHalo.html

Local ultra faint dwarves as a product of Galactic processing during a Magellanic group infall

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The recent discoveries of ultra-faint dwarf (UFD) galaxies in the vicinity of the Magellanic system supports the expectation from cosmological models that such faint objects exist and are numerous. By developing a mass model of the Local Group and backwards integrating the Magellanic Clouds’ present kinematics, we find that the locations of these UFDs are consistent with those predicted if previously associated with the Large MC as part of a loose
We further demonstrate how these satellites are likely to have been processed by the Galactic hot halo upon accretion, with the implication that ongoing detections of extremely gas-rich objects on the periphery of the Galaxy and without clear stellar counterparts are analogous to the progenitors of the gas-deficient UFDs. Our model allows us to predict the locations of other putative Magellanic satellites, and propose how their distribution/kinematics provide a novel constraint on the dynamical properties of the Galaxy. We also predict that the stripped metal-poor H\textsubscript{i}, previously associated with these UFDs, lies coincident with but distinguishable from the extensive Magellanic Stream.

Accepted for publication in MNRAS
Available from arXiv:1508.01031

Supernova 1987A: a template to link supernovæ to their remnants

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The emission of supernova remnants reflects the properties of both the progenitor supernovæ and the surrounding environment. The complex morphology of the remnants, however, hampers the disentanglement of the two contributions. Here we aim at identifying the imprint of SN 1987A on the X-ray emission of its remnant and at constraining the structure of the environment surrounding the supernova. We performed high-resolution hydrodynamic simulations describing SN 1987A soon after the core-collapse and the following three-dimensional expansion of its remnant between days 1 and 15000 after the supernova. We demonstrated that the physical model reproducing the main observables of SN 1987A during the first 250 days of evolution reproduces also the X-ray emission of the subsequent expanding remnant, thus bridging the gap between supernova and supernova remnants. By comparing model results with observations, we constrained the explosion energy in the range 1.2–1.4 \times 10^{51} \text{ erg} and the envelope mass in the range 15–17 M\textsubscript{\odot}. We found that the shape of X-ray lightcurves and spectra at early epochs (< 15 years) reflects the structure of outer ejecta: our model reproduces the observations if the outermost ejecta have a post-explosion radial profile of density approximated by a power law with index \( \alpha = -8 \). At later epochs, the shapes of X-ray lightcurves and spectra reflect the density structure of the nebula around SN 1987A. This enabled us to ascertain the origin of the multi-thermal X-ray emission, to disentangle the imprint of the supernova on the remnant emission from the effects of the remnant interaction with the environment, and to constrain the pre-supernova structure of the nebula.

Accepted for publication in The Astrophysical Journal
Available from arXiv:1508.02275

IKT 16: the first X-ray confirmed composite SNR in the SMC

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Aims: IKT 16 is an X-ray and radio-faint supernova remnant (SNR) in the Small Magellanic Cloud (SMC). A detailed X-ray study of this SNR with XMM–Newton confirmed the presence of a hard X-ray source near its centre, indicating the detection of the first composite SNR in the SMC. With a dedicated Chandra observation we aim to resolve the point source and confirm its nature. We also acquire new ATCA observations of the source at 2.1 GHz with improved flux density estimates and resolution.
Methods: We perform detailed spatial and spectral analysis of the source. With the highest resolution X-ray and radio
image of the centre of the SNR available today, we resolve the source and confirm its pulsar wind nebula (PWN)
nature. Further, we constrain the geometrical parameters of the PWN and perform spectral analysis for the point
source and the PWN separately. We also test for the radial variations of the PWN spectrum and its possible east west
asymmetry.

Results: The X-ray source at the centre of IKT 16 can be resolved into a symmetrical elongated feature centering a
point source, the putative pulsar. Spatial modeling indicates an extent of 5′′ of the feature with its axis inclined at
82° east from north, aligned with a larger radio feature consisting of two lobes almost symmetrical about the X-ray
source. The picture is consistent with a PWN which has not yet collided with the reverse shock. The point source is
about three times brighter than the PWN and has a hard spectrum of spectral index 1.1 compared to a value 2.2 for
the PWN. This points to the presence of a pulsar dominated by non-thermal emission. The expected $\dot{E} \sim 10^{37}$ erg
s$^{-1}$ and spin period < 100 ms. However, the presence of a compact nebula unresolved by Chandra at the distance of
the SMC cannot be completely ruled out.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:1508.01676
the present model, which has been previously (successfully) applied to a large sample of diffuse and translucent lines of sight in the Milky Way. We find that in the MCs the extinction produced by classical grains is generally larger than absorption by PAHs. Within this model, the nonlinear far-UV rise is accounted for by PAHs, whose presence in turn is always associated with a gap in the size distribution of classical particles. This hints either at a physical connection between (e.g., a common cause for) PAHs and the absence of middle-sized dust particles or the need for an additional component in the model that can account for the nonlinear far-UV rise without contributing to the UV bump at $\sim 217$ nm, e.g., nanodiamonds.

Accepted for publication in The Astrophysical Journal
Available from arXiv:1507.08550

The VLT-FLAMES Tarantula Survey XXIII: two massive double-lined binaries in 30 Doradus

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We investigate the characteristics of two newly discovered short-period, double-lined, massive binary systems in the Large Magellanic Cloud, VFTS 450 (O9.7 I Ib + O7:;) and VFTS 652 (B1 Ib + O9: III:). We perform model-atmosphere analyses to characterise the photospheric properties of both members of each binary (denoting the ‘primary’ as the spectroscopically more conspicuous component). Radial velocities and optical photometry are used to estimate the binary-system parameters. We estimate $T_{\text{eff}} = 27$ kK, $\log g = 2.9$ (cgs) for the VFTS 450 primary spectrum (34 kK, 3.6: for the secondary spectrum); and $T_{\text{eff}} = 22$ kK, $\log g = 2.8$ for the VFTS 652 primary spectrum (35 kK, 3.7: for the secondary spectrum). Both primaries show surface nitrogen enrichments (of more than 1 dex for VFTS 652), and probable moderate oxygen depletions relative to reference LMC abundances. We determine orbital periods of 6.89 d and 8.59 d for VFTS 450 and VFTS 652, respectively, and argue that the primaries must be close to filling their Roche lobes. Supposing this to be the case, we estimate component masses in the range $\sim 20$–50 $M_\odot$. The secondary spectra are associated with the more massive components, suggesting that both systems are high-mass analogues of classical Algol systems, undergoing case-A mass transfer. Difficulties in reconciling the spectroscopic analyses with the light-curves and with evolutionary considerations suggest that the secondary spectra are contaminated by (or arise in) accretion disks.

Accepted for publication in A&A
Available from arXiv:1508.05791

Optical discovery and multiwavelength investigation of supernova remnant MCSNR J0512−6707 in the Large Magellanic Cloud

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We present optical, radio and X-ray data that confirm a new supernova remnant (SNR) in the Large Magellanic Cloud (LMC) discovered using our deep $H_\alpha$ imagery. Optically, the new SNR has a somewhat filamentary morphology and
a diameter of 56′′ × 64′′ (13.5 × 15.5 pc² at the 49.9 kpc distance of the LMC). Spectroscopic follow-up of multiple regions show high [S\textsc{ii}]/H\textalpha emission-line ratios ranging from 0.66 ± 0.02 to 0.93 ± 0.01, all of which are typical of an SNR. We found radio counterparts for this object using our new Australia Telescope Compact Array (ATCA) 6cm pointed observations as well as a number of available radio surveys at 8 640 MHz, 4 850 MHz, 1 377 MHz and 843 MHz. With these combined data we provide a spectral index $\alpha = -0.5$ between 843 and 8640 MHz. Both spectral line analysis and the magnetic field strength, ranging from 124–184 mG, suggest a dynamical age between 2,200 and 4,700 yrs. The SNR has a previously catalogued X-ray counterpart listed as HP 483 in the ROSAT Position Sensitive Proportional Counter (PSPC) catalogue.

The VMC survey – XVI. Spatial variation of the cluster-formation activity in the innermost regions of the Large Magellanic Cloud

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We present results based on YJK\textalpha photometry of star clusters in the Large Magellanic Cloud (LMC), distributed throughout the central part of the galaxy’s bar and the 30 Doradus region. We analysed the field-star decontaminated colour–magnitude diagrams of 313 clusters to estimate their reddening values and ages. The clusters are affected by a mean reddening of $E(B - V) \in [0.2, 0.3]$ mag, where the average internal LMC reddening amounts to $\sim 0.1–0.2$ mag. The region covering 30 Doradus includes clusters with reddening values in excess of $E(B - V) = 0.4$ mag. Our cluster sample spans the age range $7.0 \leq \log(t \text{ yr}^{-1}) < 9.0$, represents an increase of 30 per cent in terms of the number of clusters with robust age estimates and comprises a statistically complete sample in the LMC regions of interest here. The resulting cluster frequencies suggest that the outermost regions of the LMC bar first experienced enhanced cluster formation – $\log(t \text{ yr}^{-1}) \in [8.5, 9.0]$ – before the activity proceeded, although in a patchy manner, to the innermost regions, for $\log(t \text{ yr}^{-1}) < 7.7$. Cluster frequencies in the 30 Doradus region show that the area is dominated by very recent cluster formation. The derived star-formation frequencies suggest that the cluster and field-star populations do not seem to have fully evolved as fully coupled systems during the last $\sim 100$ Myr.

Accepted for publication in Monthly Notices of the Royal Astronomical Society
Available from arXiv:1509.00827
Accurate star formation histories (SFHs) of galaxies are fundamental for understanding the build-up of their stellar content. However, the most accurate SFHs – those obtained from colour–magnitude diagrams (CMDs) of resolved stars reaching the oldest main sequence turnoffs (oMSTO) – are presently limited to a few systems in the Local Group. It is therefore crucial to determine the reliability and range of applicability of SFHs derived from integrated light spectroscopy, as this affects our understanding of unresolved galaxies from low to high redshift. To evaluate the reliability of current full spectral fitting techniques in deriving SFHs from integrated light spectroscopy by comparing SFHs from integrated spectra to those obtained from deep CMDs of resolved stars. We have obtained a high signal-to-noise (S/N ∼ 36.3 per Å) integrated spectrum of a field in the bar of the Large Magellanic Cloud (LMC) using EFOSC2 at the 3.6 meter telescope at La Silla Observatory. For this same field, resolved stellar data reaching the oMSTO are available. We have compared the star formation rate (SFR) as a function of time and the age–metallicity relation (AMR) obtained from the integrated spectrum using steckmap, and the CMD using the IAC-star/MinnIAC/IAC-pop set of routines. For the sake of completeness we also use and discuss other synthesis codes (STARLIGHT and ULySS) to derive the SFR and AMR from the integrated LMC spectrum. We find very good agreement (average differences ∼ 4.1%) between the SFR(t) and the AMR obtained using steckmap on the integrated light spectrum, and the CMD analysis. steckmap minimizes the impact of the age–metallicity degeneracy and has the advantage of preferring smooth solutions to recover complex SFHs by means of a penalized χ². We find that the use of single stellar populations (SSPs) to recover the stellar content, using for instance STARLIGHT or ULySS codes, hampers the reconstruction of the SFR(t) and AMR shapes, yielding larger discrepancies with respect to the CMD results. These discrepancies can be reduced if spectral templates based on known and complex SFHs instead of just single SSPs are employed.

Accepted for publication in Astronomy & Astrophysics

Available from arXiv:1509.02414
The dustiest post-main sequence stars in the Magellanic Clouds

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Using observations from the Herschel Inventory of The Agents of Galaxy Evolution (HERITAGE) survey of the Magellanic Clouds, we have found thirty five evolved stars and stellar end products that are bright in the far-infrared. These twenty eight (LMC) and seven (SMC) sources were selected from the 529 evolved star candidates in the HERITAGE far-infrared point source catalogs. Our source identification method is based on spectral confirmation, spectral energy distribution characteristics, careful examination of the multiwavelength images and includes constraints on the luminosity, resulting in a thoroughly vetted list of evolved stars. These sources span a wide range in luminosity and hence initial mass. We found thirteen low- to intermediate mass evolved stars, including asymptotic giant branch (AGB) stars, post-AGB stars, planetary nebulae and a symbiotic star. We also identify ten high mass stars, including four of the fifteen known B[e] stars in the Magellanic Clouds, three extreme red supergiants which are highly enshrouded by dust, a Luminous Blue Variable, a Wolf–Rayet star and two supernova remnants. Further, we report the detection of nine probable evolved objects which were previously undescribed in the literature. These sources are likely to be among the dustiest evolved objects in the Magellanic Clouds. The Herschel emission may either be due to dust produced by the evolved star or it may arise from swept-up ISM material.

Accepted for publication in ApJ
Available from arXiv:1508.06999

Simultaneously modelling far-infrared dust emission and its relation to CO emission in star forming galaxies

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We present a method to simultaneously model the dust far-infrared spectral energy distribution (SED) and the total infrared – carbon monoxide (CO) integrated intensity (SIR–ICO) relationship. The modelling employs a hierarchical Bayesian (HB) technique to estimate the dust surface density, temperature ($T_d$), and spectral index ($\beta_{\text{eff}}$) locally at each pixel from the observed far-infrared (IR) maps at a common resolution, such as those provided by Herschel. Additionally, given the corresponding CO map, the method simultaneously estimates the slope and intercept between the total IR and CO intensities, which are global properties of the observed source. The model accounts for both correlated and uncorrelated uncertainties, such as those present in Herschel observations. We simulate two synthetic datasets to verify the accuracy of the HB method, and contrast the results with commonly employed non-hierarchical fitting methods. As an initial application, we model the dust and gas on 100 pc scales in the Magellanic Clouds from Herschel IR and NANTEN CO observations. There is a stronger negative correlation between $T_d$ and $\beta_{\text{eff}}$ in the LMC,
with correlation coefficient $\rho \approx -0.3$, compared to the SMC, which has $\rho \approx -0.15$, suggestive of some fundamental difference in the dust properties in these galaxies. The slopes of the log SIR-log ICO relationship are similar in both galaxies. However, in the SMC the intercept is nearly 3 times higher, which can be explained by its lower metallicity resulting in a larger SIR per unit ICO compared to the LMC, which has twice the metallicity. The HB modelling evidences an increase in $T_d$ in regions with the highest CO intensities in the LMC. This may be due to enhanced dust heating in the densest molecular regions, likely from newly born stars. Such simultaneous dust and gas modelling may further reveal variations in the properties of the ISM and its association with other galactic characteristics, such as the star formation rate and/or metallicity.

Submitted to MNRAS
Available from arXiv:1509.00639

Mapping atomic and diffuse interstellar band absorption across the Magellanic Clouds and the Milky Way
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Diffuse interstellar bands (DIBs) trace warm neutral and weakly-ionized diffuse interstellar medium (ISM). Here we present a dedicated, high signal-to-noise spectroscopic survey of two of the strongest DIBs, at 5780 and 5797 Å, in optical spectra of 666 early-type stars in the Small and Large Magellanic Clouds, along with measurements of the atomic Na\textsuperscript{i} D and Ca\textsuperscript{ii} K lines. The resulting maps show for the first time the distribution of DIB carriers across large swathes of galaxies, as well as the foreground Milky Way ISM. We confirm the association of the 5797 Å DIB with neutral gas, and the 5780 Å DIB with more translucent gas, generally tracing the star-forming regions within the Magellanic Clouds. Likewise, the Na\textsuperscript{i} D line traces the denser ISM whereas the Ca\textsuperscript{ii} K line traces the more diffuse, warmer gas. The Ca\textsuperscript{ii} K line has an additional component at $\sim 200$–$220$ km s$^{-1}$ seen towards both Magellanic Clouds; this may be associated with a pan-Magellanic halo. Both the atomic lines and DIBs show sub-pc-scale structure in the Galactic foreground absorption; the 5780 and 5797 Å DIBs show very little correlation on these small scales, as do the Ca\textsuperscript{ii} K and Na\textsuperscript{i} D lines. This suggests that good correlations between the 5780 and 5797 Å DIBs, or between Ca\textsuperscript{ii} K and Na\textsuperscript{i} D, arise from the superposition of multiple interstellar structures. Similarity in behaviour between DIBs and Na\textsuperscript{i} in the SMC, LMC and Milky Way suggests the abundance of DIB carriers scales in proportion to metallicity.

Accepted for publication in MNRAS
Available from arXiv:1509.05319

On the magnetic fields of Be/X-ray pulsars in the Small Magellanic Cloud
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We explore the possibility to explain the properties of the Be/X-ray pulsars observed in the Small Magellanic Cloud within the magnetic levitation accretion scenario. This implies that their X-ray emission is powered by a wind-fed accretion onto a neutron star (NS) which captures matter from a magnetized stellar wind. The NS in this case is
accreting matter from a non-Keplerian magnetically levitating disc (ML-disc) which is surrounding its magnetosphere. This allows us to explain the observed periods of the pulsars in terms of spin equilibrium without the need of invoking dipole magnetic fields outside the usual range $10^{11} - 10^{13}$ G inferred from cyclotron features of Galactic high mass X-ray binaries. We find that the equilibrium period of a NS, under certain conditions, depends strongly on the magnetization of the stellar wind of its massive companion and, correspondingly, on the magnetic field of the massive companion itself. This may help to explain why similar NSs in binaries with similar properties rotate with different periods yielding a large scatter of periods of the accretion-powered pulsar observed in SMC and our galaxy.

Accepted for publication in MNRAS
Available from arXiv:1509.03865

Post-AGB stars in the Magellanic Clouds and neutron-capture processes in AGB stars

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We explore modifications to the current scenario for the slow ($s$) neutron capture process in asymptotic giant branch (AGB) stars to account for the Pb deficiency observed in post-AGB stars of low metallicity ([Fe/H] $\simeq -1.2$) and low initial mass ($\simeq 1$–1.5 $M_\odot$) in the Large and Small Magellanic Clouds. We calculated the stellar evolution and nucleosynthesis for a 1.3 $M_\odot$ star with [Fe/H] $=-1.3$ and tested different amounts and distributions of protons leading to the production of the main neutron source within the $^{13}$C-pocket and proton ingestion scenarios. No $s$-process models can fully reproduce the abundance patterns observed in the post-AGB stars. When the Pb production is lowered the abundances of the elements between Eu and Pb, such as Er, Yb, W, and Hf, are also lowered to below those observed. Neutron-capture processes with neutron densities intermediate between the $s$ and the rapid ($r$) neutron-capture processes may provide a solution to this problem and be a common occurrence in low-mass, low-metallicity AGB stars.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:1509.03518

Conference Papers

Star formation in the Local Group as seen by low-mass stars

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We have undertaken a systematic study of pre-main sequence (PMS) stars spanning a wide range of masses (0.5–4 $M_\odot$), metallicities (0.1–1 $Z_\odot$) and ages (0.5–30 Myr). We have used the Hubble Space Telescope (HST) to identify and characterise a large sample of PMS objects in several star-forming regions in the Magellanic Clouds, namely 30 Dor and the SN 1987A field in the LMC, and NGC 346 and NGC 602 in the SMC, and have compared them to PMS stars in
similar regions in the Milky Way, such as NGC 3603 and Trumpler 14, which we studied with the HST and Very Large Telescope (VLT). We have developed a novel method that combines broad-band (V, I) photometry with narrow-band Hα imaging to determine the physical parameters (temperature, luminosity, age, mass and mass accretion rate) of more than 3000 bona-fide PMS stars still undergoing active mass accretion. This is presently the largest and most homogeneous sample of PMS objects with known physical properties and includes not only very young objects, but also PMS stars older than 10–20 Myr that are approaching the main sequence (MS). We find that the mass accretion rate scales roughly with the square root of the age, with the mass of the star to the power of 1.5, and with the inverse of the cube root of the metallicity. The mass accretion rates for stars of the same mass and age are thus systematically higher in the Magellanic Clouds than in the Milky Way. These results are bound to have important implications for, and constraints on our understanding of the star formation process.

Available from arXiv:1508.07320

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Do you know the extinction in your young massive cluster?

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Up to ages of \( \sim 100 \) Myr, massive clusters are still swamped in large amounts of gas and dust, with considerable and uneven levels of extinction. At the same time, large grains (ices?) produced by type II supernovae profoundly alter the interstellar medium (ISM), thus resulting in extinction properties very different from those of the diffuse ISM. To obtain physically meaningful parameters of stars, from basic luminosities and effective temperatures to masses and ages, we must understand and measure the local extinction law. This problem affects all the massive young clusters discussed in his volume. We have developed a powerful method to unambiguously determine the extinction law in an uniform way across a cluster field, using multi-band photometry of red giant stars belonging to the red clump (RC). In the Large Magellanic Cloud, with about 20 RC stars per arcmin\(^2\), we can easily derive a solid and self-consistent absolute extinction curve over the entire wavelength range of the photometry. Here, we present the extinction law of the Tarantula nebula (30 Dor) based on thousands of stars observed as part of the Hubble Tarantula Treasury Project.

Available from arXiv:1509.02906

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Disk tracing for B[e] supergiants in the Magellanic Clouds

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B[e] supergiants are evolved massive stars with a complex circumstellar environment. A number of important emission features probe the structure and the kinematics of the circumstellar material. In our survey of Magellanic Cloud B[e] supergiants we focus on the \([\text{O}i]\) and \([\text{Ca}ii]\) emission lines, which we identified in four more objects.

Poster contribution, published in "Physics of Evolved Stars" – a conference dedicated to the memory of Olivier Chesneau, Nice, France, June 8–12, 2015
Available from arXiv:1507.08443
Decades-long repeat observations of supernova SN1987A offer us unique, real-time insights into the violent death of a massive star and its long-term environmental effects, until its eventual switch-off.

Published in Nature Physics, 11, 623 (2015) – News & Views
Available from arXiv:1507.08770

The meeting “Supernova Remnants: An Odyssey in Space after Stellar death” will explore the exciting recent observational and theoretical progress in the structure, evolution and physics of SNRs. The Institute for Astronomy, Astrophysics, Space Applications & Remote Sensing of the National Observatory of Athens, invites you to the beautiful island of Crete, the home of many well known myths, i.e. of Dædalus and Icarus, Theseus and the Minotaur, the birth of Zeus.

The conference will build upon spectral and imaging observations from radio to γ-ray wavelengths of SNR blast waves, pulsar wind nebulae and SN ejecta and their interpretation through models and numerical simulations. The goals of the meeting are understanding the evolution of SNRs and their interaction with interstellar gas, elucidating the physical processes that govern shock waves and relativistic plasmas, and inferring characteristics of supernova explosions from SNR observations.

We will focus on narrowing the gap between observations and theories with the help of powerful new instrumentation such as hard X-ray and γ-ray satellites, large optical telescopes, and sub-mm and low-frequency radio arrays on the one hand, and increasingly detailed and realistic numerical simulations on the other. New understanding of the nature of supernova remnants and processes that occur there offers new insights into the role of SNRs in the structure and evolution of galaxies and the nature of supernova explosions.

Looking forward to seeing you in Crete!

Scientific Topics & Session Chairs
- Radiation studies from γ-rays to radio in Galactic and Extragalactic SNRs (D. Green)
- The search for the binary companions of SN progenitors in SNRs (W. Blair)
- Pulsar winds nebulae (including Crab flares) (P. Slane)
- Magnetic fields in SNRs and PWNe (R. Kothes)
• Collisionless shock waves in SNRs (A. Decourcelle)
• Jets and Asymmetries in SNe and their Remnants (R. Fesen)
• SNRs as probes and drivers of galaxy structure (A. Rest)
• SNe and SNRs cosmic ray acceleration (T. Bell)
• SN ejecta & abundances, clumpiness (K. Borkowski)
• SNe and SNRs with circumstellar interactions (J. Raymond)

Invited Speakers (confirmed): R. Chevalier (USA – opening plenary talk), J. Vink (Netherlands – summary plenary talk), E. Amato (Italy), C. Badenes (USA), G. Dubner (Argentina), P. Ghavamian (USA), W. Kerzendorf (Canada), S-H. Lee (Japan), M. Lemoine-Goumard (France), I. Leonidaki (Greece), L. Lopez (USA), R. McCray (USA), D. Milisavljević (USA), D. Patnaude (USA), W. Reich (Germany), S. Reynolds (USA), S. Safi-Harb (Canada), N. Soker (Israel), T. Temim (USA), S. Van Dyk (USA), B. Williams (USA)

See also http://snr2016.astro.noa.gr/