Dear Colleagues,

It is my pleasure to present you the 160th issue of the Magellanic Clouds Newsletter.

I would like to point you in particular in the direction of two a little more unusual but nonetheless very exciting papers on fundamental Physics: modified gravity tested by SN 1987, by Eroshenko et al., and a test of the weak equivalence principle, by Levshakov et al.

Note also that in addition to journal and conference proceedings papers, we welcome “opinion” pieces, that can be submitted as announcements. These could describe novel views on contemporary topics, highlight unsolved problems or disagreements, or propose new avenues of research.

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

Editorially Yours,
Jacco van Loon
A census of massive stars in NGC 346

P.L. Dufton¹, C.J. Evans², I. Hunter¹, D.J. Lennon³ and F.R.N. Schneider⁴,⁵

¹Astrophysics Research Centre, School of Mathematics & Physics, The Queen’s University of Belfast, Belfast, BT7 1NN, UK
²UK Astronomy Technology Centre, Royal Observatory, Blackford Hill, Edinburgh, EH9 3HJ, UK
³Instituto de Astrofísica de Canarias, E-38205 La Laguna, Tenerife, Spain
⁴Zentrum für Astronomie der Universität Heidelberg, Astronomisches Rechen-Institut, Mönchhofstr. 12–14, 69120 Heidelberg, Germany
⁵Heidelberger Institut für Theoretische Studien, Schloß-Wolfsbrunnenweg 35, 69118 Heidelberg, Germany

Spectroscopy for 247 stars towards the young cluster NGC 346 in the Small Magellanic Cloud has been combined with that for 116 targets from the VLT-FLAMES Survey of Massive Stars. Spectral classification yields a sample of 47 O-type and 287 B-type spectra, while radial-velocity variations and/or spectral multiplicity have been used to identify 45 candidate single-lined (SB1) systems, 17 double-lined (SB2) systems, and one triple-lined (SB3) system. Atmospheric parameters and projected rotational velocities have been estimated using TLUSTY model atmospheres; independent estimates of the projected rotational velocity were also obtained using a Fourier Transform method. Luminosities have been inferred from stellar apparent magnitudes and used in conjunction with the effective temperature and projected rotational velocity estimates to constrain stellar masses and ages using the BONNSAI package. We find that targets towards the inner region of NGC 346 have higher median masses and projected rotational velocities, together with smaller median ages than the rest of the sample. There appears to be a population of very young targets with ages of less than 2 Myr, which have presumably all formed within the cluster. The more massive targets are found to have lower projected rotational velocities consistent with previous studies. No significant evidence is found for differences with metallicity in the stellar rotational velocities of early-type stars, although the targets in the Small Magellanic Cloud may rotate faster than those in young Galactic clusters. The rotational velocity distribution for single non-supergiant B-type stars is inferred and implies that a significant number have low rotational velocity (≃ 10% with \( v_{eq} \approx 40 \text{ km s}^{-1} \)), together with a peak in the probability distribution at \( v_{eq} \approx 300 \text{ km s}^{-1} \). Larger projected rotational velocity estimates have been found for our Be-type sample and imply that most have rotational velocities between 200–450 km s⁻¹.

Accepted for publication in Astronomy & Astrophysics

A massive nebula around the Luminous Blue Variable star RMC 143 revealed by ALMA

C. Agliozzo¹,²,³, A. Mehner¹, N.M. Phillips², P. Leto⁴, J.H. Groh⁵, A. Noriega-Crespo⁶, C. BUemi⁴, F. Cavallaro⁴, L. Cerrigone⁷, A. Ingallinera⁴, R. Paladini⁸, G. Pignata⁸,⁹, C. Trigilio⁴ and G. Umana⁴

¹European Southern Observatory, Chile
²European Southern Observatory, Germany
³Universidad Andrés Bello, Chile
⁴INAF-OACT, Italy
⁵Trinity College Dublin, Ireland
⁶Space Telescope Science Institute, USA
⁷Joint ALMA Observatory, Chile
⁸Infrared Processing Analysis Center, USA
⁹Millennium Institute of Astrophysics, Chile

The luminous blue variable (LBV) RMC 143 is located in the outskirts of the 30Doradus complex, a region rich with interstellar material and hot luminous stars. We report the 3σ sub-millimetre detection of its circumstellar nebula with ALMA. The observed morphology in the sub-millimetre is different than previously observed with HST.
Possible explanation of the Geograv detector signal during the explosion of SN 1987A in modified gravity models

Yu.N. Eroshenko¹, E.O. Babichev², V.I. Dokuchaev¹,³ and A.S. Malgin¹

¹Institute for Nuclear Research, Russian Academy of Sciences, Russia
²Univ. Paris-Sud, Université Paris–Saclay, France
³National Research Nuclear University MEPhI, Russia

A change in gravity law in some regimes is predicted in the modified gravity models that are actively discussed at

Reddening map and recent star formation in the Magellanic Clouds based on OGLE IV Cepheids

Yogesh Chandra Joshi³ and Alaxender Panchal⁴

We examine reddening distribution across the LMC and SMC through largest data on Classical Cepheids provided by the OGLE Phase IV survey. The $V$ and $I$ band photometric data of 2476 fundamental mode (FU) and 1775 first overtone mode (FO) Cepheids in the LMC and 2753 FU and 1793 FO Cepheids in the SMC are analyzed for their Period–Luminosity (P–L) relations. We convert period of FO Cepheids to corresponding period of FU Cepheids before combining the two modes of Cepheids. The reddening analysis is performed on 133 segments covering a total area of about 154.6 deg² in the LMC and 136 segments covering a total area of about 31.3 deg² in the SMC. By comparing with well calibrated P–L relations of these two galaxies, we determine reddening $E(V − I)$ in each segment. Using reddening values in different segments across the LMC and SMC, reddening maps are constructed. We find clumpy structures in the reddening distributions of the LMC and SMC. From the reddening map of the LMC, highest reddening of $E(V − I) = 0.466$ mag is traced in the region centered at $RA ≈ 85°13$, $Dec ≈ −69°34$ which is in close vicinity of the star forming H I region 30 Doradus. In the SMC, maximum reddening of $E(V − I) = 0.189$ mag is detected in the region centered at $RA ≈ 12°10$, $Dec ≈ −73°07$. The mean reddening values in the LMC are estimated as $E(V − I) = 0.113 ± 0.060$ mag and $E(B − V) = 0.091 ± 0.050$ mag; and that in the SMC are $E(V − I) = 0.049 ± 0.070$ mag and $E(B − V) = 0.038 ± 0.053$ mag. The period–age relations are used to derive the age of the Cepheid populations in the LMC and SMC. We investigate age and spatio-temporal distributions of Cepheids to understand the recent star formation history in the Magellanic Clouds (MCs) and found an evidence of a common enhanced Cepheid population in the MCs at around 200 Myr ago which appears to have occurred due to close encounter between the two clouds.

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Reddening map and recent star formation in the Magellanic Clouds based on OGLE IV Cepheids

Yogesh Chandra Joshi³ and Alaxender Panchal⁴

We examine reddening distribution across the LMC and SMC through largest data on Classical Cepheids provided by the OGLE Phase IV survey. The $V$ and $I$ band photometric data of 2476 fundamental mode (FU) and 1775 first overtone mode (FO) Cepheids in the LMC and 2753 FU and 1793 FO Cepheids in the SMC are analyzed for their Period–Luminosity (P–L) relations. We convert period of FO Cepheids to corresponding period of FU Cepheids before combining the two modes of Cepheids. The reddening analysis is performed on 133 segments covering a total area of about 154.6 deg² in the LMC and 136 segments covering a total area of about 31.3 deg² in the SMC. By comparing with well calibrated P–L relations of these two galaxies, we determine reddening $E(V − I)$ in each segment. Using reddening values in different segments across the LMC and SMC, reddening maps are constructed. We find clumpy structures in the reddening distributions of the LMC and SMC. From the reddening map of the LMC, highest reddening of $E(V − I) = 0.466$ mag is traced in the region centered at $RA ≈ 85°13$, $Dec ≈ −69°34$ which is in close vicinity of the star forming H I region 30 Doradus. In the SMC, maximum reddening of $E(V − I) = 0.189$ mag is detected in the region centered at $RA ≈ 12°10$, $Dec ≈ −73°07$. The mean reddening values in the LMC are estimated as $E(V − I) = 0.113 ± 0.060$ mag and $E(B − V) = 0.091 ± 0.050$ mag; and that in the SMC are $E(V − I) = 0.049 ± 0.070$ mag and $E(B − V) = 0.038 ± 0.053$ mag. The period–age relations are used to derive the age of the Cepheid populations in the LMC and SMC. We investigate age and spatio-temporal distributions of Cepheids to understand the recent star formation history in the Magellanic Clouds (MCs) and found an evidence of a common enhanced Cepheid population in the MCs at around 200 Myr ago which appears to have occurred due to close encounter between the two clouds.

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In this paper, we consider a possibility that the signal recorded by the Geograv resonant gravitational-wave detector in 1987 during the explosion of SN 1987A was produced by an abrupt change in the metric during the passage of a strong neutrino flux through the detector. Such an impact on the detector is possible, in particular, in extended scalar-tensor theories in which the local matter density gradient affects the gravitational force. The first short neutrino pulse emitted at the initial stage of stellar core collapse before the onset of neutrino opacity could exert a major influence on the detector by exiting the detector response at the main resonance frequency. In contrast, the influence of the subsequent broad pulse (with a duration of several seconds) in the resonant detector is exponentially suppressed, despite the fact that the second pulse carries an order-of-magnitude more neutrino energy, and it could generate a signal in the LSD neutrino detector. This explains the time delay of 1.4s between the Geograv and LSD signals. The consequences of this effect of modified gravity for LIGO/Virgo observations are discussed.


12CO and 13CO $J = 3–2$ observations toward N 11 in the Large Magellanic Cloud

M. Celis Peña1, S. Paron1, M. Rubio2, C.N. Herrera3 and M.E. Ortega1

1CONICET – Universidad de Buenos Aires, Instituto de Astronomía y Física del Espacio, CC 67, Suc. 28, 1428 Buenos Aires, Argentina
2Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Santiago, Chile
3Institut de Radioastronomie Millimétrique, 300 Rue de la Piscine, 38406 Saint-Martin-d’Hères, France

After 30 Doradus, N 11 is the second largest and brightest nebula in the Large Magellanic Cloud (LMC). This large nebula has several OB associations with bright nebulae at its surroundings. N 11 was previously mapped at the lowest rotational transitions of 12CO ($J = 1–0$ and 2–1), and in some particular regions pointings of the 13CO $J = 1–0$ and 2–1 lines were also performed. Observations of higher CO rotational transitions are needed to map gas with higher critical densities, useful to study in a more accurate way the physical conditions of the gas component and its relation with the UV radiation. Using the Atacama Submillimeter Telescope Experiment we mapped the whole extension of the N 11 nebula in the 12CO $J = 3–2$ line, and three sub-regions in the 13CO $J = 3–2$ line. The regions mapped in the 13CO $J = 3–2$ were selected based on that they may be exposed to the radiation at different ways: a region lying over the nebula related to the OB association LH 10 (N 11B), another one that it is associated with the southern part of the nebula related to the OB association LH 13 (N 11D), and finally a farther area at the South–West without any embedded OB association (N 11I). We found that the morphology of the molecular clouds lying in each region shows some signatures that could be explained by the expansion of the nebulae and the action of the radiation. Fragmentation generated in a molecular shell due to the expansion of the N 11 nebula is suggested. The integrated line ratios 12CO/13CO show evidences of selective photodissociation of the 13CO, and probably other mechanisms such as chemical fractionation. The values found for the integrated line ratios 12CO $J = 3–2/1–0$ are in agreement with values that were assumed in previous works, and the CO contribution to the continuum at 870 μm was directly derived. The distribution of the integrated line ratios 12CO $J = 3–2/2–1$ show hints of stellar feedback in N 11B and N 11D. The ratio between the virial and LTE mass ($M_{\text{vir}}/M_{\text{LTE}}$) is higher than unity in all analyzed molecular clumps, which suggests that the clumps are not gravitationally bounded and may be supported by external pressure. A non-LTE analysis suggests that we are mapping gas with densities about a few $10^3$ cm$^{-3}$. The molecular clump at N 11B, the unique molecular feature with direct evidence of ongoing star formation, is the densest one among the analyzed clumps.

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Testing the weak equivalence principle by differential measurements of fundamental constants in the Magellanic Clouds

S.A. Levshakov 1,2, K.-W. Ng3,4, C. Henkel5,6, B. Mookerjea7, I.I. Agafonova2, S.-Y. Liu4 and W.-H. Wang4

1Ioffe Physical-Technical Institute, 194021 St. Petersburg, Russia
2Electrotechnical University ‘LETI’, 197376 St. Petersburg, Russia
3Institute of Physics, Academy Sinica, Taipei 11529, Taiwan
4Institute of Astronomy and Astrophysics, Academy Sinica, Taipei 11529, Taiwan
5Max Planck Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany
6Astron. Dept., King Abdulazia University, P.O. Box 80203, 21589 Jeddah, Saudi Arabia
7Tata Institute of Fundamental Research, Homi Bhabha Road, 400005 Mumbai, India

Non-standard fields are assumed to be responsible for phenomena attributed to dark energy and dark matter. Being coupled to ordinary matter, these fields modify the masses and/or charges of the elementary particles, thereby violating the Weak Equivalence Principle. Thus, values of fundamental constants such as the proton-to-electron mass ratio, $\mu$, and/or the fine structure constant, $\alpha$, measured in different environment conditions can be used as probes for this coupling. Here we perform differential measurements of $F = \mu \cdot \alpha^2$ to test a non-standard coupling in the Magellanic Clouds – dwarf galaxies where the overall mass budget is dominated by dark matter. The analysis is based on [C i] and CO lines observed with the Herschel Space Observatory. Since these lines have different sensitivities to changes in $\mu$ and $\alpha$, the combined $\alpha$ and $\mu$ variations can be evaluated through the radial velocity offsets, $\Delta V$, between the CO and [C i] lines. Averaging over nine positions in the Magellanic Clouds, we obtain $\langle \Delta V \rangle = -0.02 \pm 0.07 \, \text{km s}^{-1}$, leading to $|\Delta F/F| < 2 \cdot 10^{-7}$ (1 $\sigma$), where $\Delta F/F = (F_{\text{obs}} - F_{\text{lab}})/F_{\text{lab}}$. However, for one position observed with five times higher spectral resolution we find $\Delta V = -0.05 \pm 0.02 \, \text{km s}^{-1}$, resulting in $\Delta F/F = (1.7 \pm 0.7) \cdot 10^{-7}$. Whether this offset is due to changes in the fundamental constants, due to chemical segregation in the emitting gas or merely due to Doppler noise requires further investigations.

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Targeted search for young radio pulsars in the SMC: Discovery of two new pulsars

N. Titus1,2, B.W. Stappers3, V. Morello3, M. Caleb3,4,5,6, M.D. Filipović7, V.A. McBride1,2,8, W.C.G. Ho9,10 and D.A.H. Buckley2

1Department of Astronomy, University of Cape Town, Private Bag X3, Rondebosch, 7701, South Africa
2South African Astronomical Observatory, P.O. Box 9, Observatory, 7935, South Africa
3Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, Manchester M13 9PL, UK
4Research School of Astronomy and Astrophysics, Australian National University, ACT, 2611, Australia
5Centre for Astrophysics and Supercomputing, Swinburne University of Technology, P.O. Box 218, Hawthorn, VIC 3122, Australia
6ARC Centre of Excellence for All-sky Astrophysics (CAASTRO), Australia
7Western Sydney University, Locked Bag 1797, Penrith South DC, NSW 1797, Australia
8IAU Office of Astronomy for Development, Cape Town, South Africa
9Department of Physics and Astronomy, Haverford College, 370 Lancaster Avenue, Haverford, PA 19041 USA
10Mathematical Sciences, Physics and Astronomy and STAG Research Centre, University of Southampton, SO17 1BJ, UK

We report the first rotation powered pulsars discovered in the Small Magellanic Cloud (SMC) in more than a decade. PSR J0043–73 and PSR J0052–72 were discovered during a Parkes Multi-Beam (PMB) survey of MCSNR J0127–7332, and five new, optically selected, supernova remnant (SNR) candidates identified by the XMM–Newton survey. In addition to the candidates, we adjusted the PMB rotation to include additional nine SNRs and pulsar wind nebulae. We searched for young pulsars (1–200 ms) employing a Fourier analysis with presto, as well as a search for longer period pulsars (200 ms – 360 s) with a fast folding algorithm. Our targeted survey had a limiting flux density of 0.039 mJy for periods greater than 50 ms. Although not the main target of this search it was also sensitive to
millisecond pulsars. PSR J0043−73 has a period and dispersion measure of 937.429 37 (26) ms and 115.1 (3.4) pc cm$^{-3}$, respectively, and PSR J0052−72 has a period of 191.444 328 (46) ms and a DM of 158.6 (1.6) pc cm$^{-3}$.

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**Clues on the origin and evolution of massive contact binaries: atmosphere analysis of VFTS 352**


1Institute of Astrophysics, K.U. Leuven, Celestijnenlaan 200 D, 3001 Leuven, Belgium
2Astronomical Institute Anton Pannekoek, Amsterdam University, Science Park 904, 1098 XH, Amsterdam, The Netherlands
3Departamento de Física Teórica e Experimental, Universidade Federal do Rio Grande do Norte, C.P. 1641, Natal, RN, 59072-970, Brazil
4School of Astronomy & Space Science, University of the Chinese Academy of Sciences, Beijing 100012, China
5Argelander-Institut für Astronomie, Universität Bonn, Auf dem Hügel 71, 53121 Bonn, Germany
6LMU München, Universitätssternwarte, Scheinerstr. 1, 81679 München, Germany
7Institute for Astronomy, Astrophysics, Space Applications & Remote Sensing, National Observatory of Athens, P. Penteli, 15236 Athens, Greece

The massive O4.5 V + O5.5 V binary VFTS 352 in the Tarantula nebula is one of the shortest-period and most massive over-contact binaries known. Recent theoretical studies indicate that some of these systems could ultimately lead to the formation of gravitational waves via black hole binary mergers through the chemically homogeneous evolution pathway. By analyzing ultraviolet–optical phase-resolved spectroscopic data, we aim to constrain atmospheric and wind properties that could be later used to confront theoretical predictions from binary evolution. In particular, surface abundances are powerful diagnostics of the evolutionary status, mass transfer and the internal mixing processes. From a set of 32 VLT/FLAMES visual and 8 HST/COS ultraviolet spectra, we used spectral disentangling to separate the primary and secondary components. Using a genetic algorithm wrapped around the NLTE model atmosphere and spectral synthesis code FASTWIND, we perform an 11-parameter optimization to derive the atmospheric and wind parameters of both components, including the surface abundances of He, C, N, O and Si. We find that both components are hotter than expected compared to single-star evolutionary models indicating that additional mixing processes may be at play. However the derived chemical abundances do not show significant indications of mixing when adopting baseline values typical for the system environment.

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**The metallicity sensitivity of a surface brightness temperature scale**

**Jeremy Mould**

1Centre for Astrophysics & Supercomputing, Swinburne University, PO Box 218, Hawthorn, Vic 3122, Australia

To obtain the accuracy now sought in the extragalactic distance scale through standard candles and rulers, calibration of stellar photometry must be improved. The sensitivity of the V−K color surface brightness relation is examined here by means of model atmosphere fluxes. It has previously been neglected, but is shown here to be a significant term in the error budget of a recent high precision distance of the Large Magellanic Cloud, an anchor in galaxy distances based on Cepheids.

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On the photometric signature of fast rotators

Léo Girardi1, Guglielmo Costa2, Yang Chen3, Paul Goudfrooij4, Alessandro Bressan2, Paola Marigo3 and Andrea Bellini4

1Osservatorio Astronomico di Padova – INAF, Vicolo dell’Osservatorio 5, I-35122 Padova, Italy
2SISSA, via Bonomea 365, I-34136 Trieste, Italy
3Dipartimento di Fisica e Astronomia Galileo Galilei, Università di Padova, Vicolo dell’Osservatorio 3, I-35122 Padova, Italy
4Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA

Rapidly rotating stars have been recently recognized as having a major role in the interpretation of colour–magnitude diagrams of young and intermediate-age star clusters in the Magellanic Clouds and in the Milky Way. In this work, we evaluate the distinctive spectra and distributions in colour–colour space that follow from the presence of a substantial range in effective temperatures across the surface of fast rotators. The calculations are inserted in a formalism similar to the one usually adopted for non-rotating stars, which allows us to derive tables of bolometric corrections as a function not only of a reference effective temperature, surface gravity and metallicity, but also of the rotational speed with respect to the break-up value, ω, and the inclination angle, i. We find that only very fast rotators (ω > 0.95) observed nearly equator-on (i > 45°) present sizable deviations from the colour-relation colours of nonrotating stars. In light of these results, we discuss the photometry of the ∼200-Myr-old cluster NGC 1866 and its split main sequence, which has been attributed to the simultaneous presence of slow and fast rotators. The small dispersion of its stars in colour–colour diagrams allow us to conclude that fast rotators in this cluster either have rotational velocities ω < 0.95, or are all observed nearly pole-on. Such geometric colour–colour effects, although small, might be potentially detectable in the huge, high-quality photometric samples in the post-Gaia era, in addition to the evolutionary effects caused by rotation-induced mixing.

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Variable dust emission by WC type Wolf–Rayet stars observed in the NEOWISE-R survey

P.M. Williams1

1Institute for Astronomy, University of Edinburgh, Royal Observatory, Edinburgh, Scotland

Photometry at 3.4 and 4.6 μm of 128 Population I WC type Wolf–Rayet stars in the Galaxy and 12 in the Large Magellanic Cloud (LMC) observed in the WISE NEOWISE-R survey was searched for evidence of circumstellar dust emission and its variation. Infrared spectral energy distributions (SEDs) were assembled, making use of archival r, i, Z and Y photometry to determine reddening and stellar wind levels for the WC stars found in recent IR surveys and lacking optical photometry. From their SEDs, ten apparently non-variable stars were newly identified as dust makers, including three, WR 102-22, WR 110-10 and WR 124-10, having subtype earlier than WC8–9, the first such stars to show this phenomenon. The 11 stars found to show variable dust emission include six new episodic dust-makers, WR 47c, WR 75-11, WR 91-1, WR 122-14 and WR 125-1 in the Galaxy and HD 38030 in the LMC. Of previously known dust makers, NEOWISE-R photometry of WR 19 captured its rise to maximum in 2018 confirming the 10.1-y period, that of WR 125 the beginning of a new episode of dust formation suggesting a period near 28.3 y. whle that of HD 36402 covered almost a whole period and forced revision of it to 5.1 y.

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Final release of the OGLE collection of Cepheids and RR Lyræ stars in the Magellanic System. The outer regions

I. Soszyński¹, A. Udalski¹, K. Szymański¹, P. Pietrukowicz¹, J. Skowron¹, D. Skowron¹, R. Poleski², S. Kozłowski¹, P. Mróz¹, K. Ulaczyk³, K. Rybicki¹, P. Iwanek¹ and M. Wrona¹

¹Warsaw University Observatory, Al. Ujazdowskie 4, PL-00-478 Warszawa, Poland
²Department of Astronomy, Ohio State University, 140 W. 18th Ave., Columbus, OH 43210, USA
³Department of Physics, University of Warwick, Gibbet Hill Road, Coventry, CV4 7AL, UK

We present the final release of the OGLE collection of classical pulsators (Cepheids and RR Lyr stars) in the Large and Small Magellanic Clouds. The sky coverage has been increased from 670 to 765 square degrees compared to the previous edition of our collection. We also add some Cepheids and RR Lyr stars found by the Gaia team and reclassify three Cepheids. Ultimately, our collection consists of 965 0 classical Cepheids, 343 type II Cepheids, 278 anomalous Cepheids, and 47 828 RR Lyr stars inside and toward the Magellanic System.

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Radiative and mechanical feedback into the molecular gas in the Large Magellanic Cloud. II. 30 Doradus

Min-Young Lee¹,²,³, Suzanne Madden², Franck Le Petit⁴, Antoine Gusdorf⁵, Pierre Lesaffre⁵, Ronin Wu⁴, Vianney Lebouteiller⁵, Frédéric Galliano⁵ and Mélanie Chevance⁶

¹Max Planck Institute for Radio Astronomy, Germany
²CEA-Saclay, France
³Korea Astronomy & Space Science Institute, South Korea
⁴Paris Observatory, France
⁵ENS, France
⁶University of Heidelberg, Germany

With an aim of probing the physical conditions and excitation mechanisms of warm molecular gas in individual star-forming regions, we performed Herschel SPIRE FTS observations of 30 Doradus in the LMC. In our FTS observations, important FIR cooling lines in the ISM, including CO J = 4–3 to 13–12, [C i] 370 µm, and [N II] 205 µm, were clearly detected. In combination with ground-based CO data, we then constructed CO spectral line energy distributions (SLEDs) on ~10-pc scales over a ~60 pc × 60 pc area and found that the shape of the observed CO SLEDs considerably changes across 30 Doradus, e.g., the peak transition varies from J = 6–5 to 10–9, while the slope characterized by the high-to-intermediate J ratio α ranges from ~0.4 to ~1.8. To examine the source(s) of these variations in CO transitions, we analyzed the CO observations, along with [C ii] 158 µm, [C i] 370 µm, [O i] 145 µm, H₂ 0–0 S(3), and FIR luminosity data, using state-of-the-art models of PDRs and shocks. Our detailed modeling showed that the observed CO emission likely originates from highly-compressed (thermal pressure P/k_B ~ 10⁷–10⁹ K cm⁻³) clumps on ~0.7–2 pc scales, which could be produced by either UV photons (UV radiation field G_UV ~ 10⁵–10⁶ Mathis fields) or low-velocity C-type shocks (pre-shock medium density n_{pre} ~ 10⁴–10⁶ cm⁻³ and shock velocity v_s ~ 5–10 km s⁻¹). Considering the stellar content in 30 Doradus, however, we tentatively excluded the stellar origin of CO excitation and concluded that low-velocity shocks driven by ~kpc-scale processes (e.g., interaction between the Milky Way and the Magellanic Clouds) are likely the dominant source of heating for CO. The shocked CO-bright medium was then found to be warm (temperature T ~ 100–500 K) and surrounded by a UV-regulated low pressure component (P/k_B ~ a few 10⁴–10⁵ K cm⁻³) that is bright in [C ii] 158 µm, [C i] 370 µm, [O i] 145 µm, and FIR dust continuum emission.

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Evolved massive stars at low metallicity I. A source catalog for the Small Magellanic Cloud

Ming Yang, Alceste Z. Bonanos, Bi-Wei Jiang, Jian Gao, Panagiotis Gavras, Grigoris Maravelias, Yi Ren, Shu Wang, Meng-Yao Xue, Frank Tramper, Zoi T. Spetsieri and Ektoras Pouliasis

1IAASARS, National Observatory of Athens, Vas. Pavlou and I. Metaxa, Penteli 15236, Greece
2Department of Astronomy, Beijing Normal University, Beijing 100875, People’s Republic of China
3Rhea Group for ESA/ESAC, Camino bajo del Castillo, s/n, Urbanización Villafranca del Castillo, Villanueva de la Cañada, 28692 Madrid, Spain
4Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Datun Road 20A, Beijing 100101, People’s Republic of China
5International Centre for Radio Astronomy Research, Curtin University, Bentley, WA 6102, Australia
6Department of Astrophysics, Astronomy & Mechanics, Faculty of Physics, University of Athens, Zografos, 15783 Athens, Greece

We present a clean, magnitude-limited (IRAC1 or WISE1 ≤ 15.0 mag) multiwavelength source catalog for the Small Magellanic Cloud (SMC) with 45,466 targets in total, with the purpose of building an anchor for future studies, especially for the massive star populations at low metallicity. The catalog contains data in 50 different bands including 21 optical and 29 infrared bands, retrieved from SEIP, VMC, IRSF, AKARI, HERITAGE, Gaia, SkyMapper, NSC, Massey et al. (2002), and GALEX, ranging from the ultraviolet to the far-infrared. Additionally, radial velocities and spectral classifications were collected from the literature, as well as infrared and optical variability statistics were retrieved from WISE, SAGE-Var, VMC, IRSF, Gaia, NSC, and OGLE. The catalog was essentially built upon a 1″ crossmatching and a 3″ deblending between the Spitzer Enhanced Imaging Products (SEIP) source list and Gaia Data Release 2 (DR2) photometric data. Further constraints on the proper motions and parallaxes from Gaia DR2 allowed us to remove the foreground contamination. We estimated that about 99.5% of the targets in our catalog were most likely genuine members of the SMC. By using the evolutionary tracks and synthetic photometry from MESA isochrones and stellar tracks and the theoretical (J − K_s) color cuts, we identified 1,405 red supergiant, 217 yellow supergiant, and 1,369 blue supergiant candidates in the SMC in five different color–magnitude diagrams (CMDs), where attention should also be paid to the incompleteness of our sample. We ranked the candidates based on the intersection of different CMDs. A comparison between the models and observational data shows that the lower limit of initial mass for the RSGs population may be as low as 7 or even 6 M_⊙ and the RSG is well separated from the asymptotic giant branch star (AGB) population even at faint magnitude, making RSGs a unique population connecting the evolved massive and intermediate stars, since stars with initial mass around 6 to 8 M_⊙ are thought to go through a second dredge-up to become AGB stars. We encourage the interested reader to further exploit the potential of our catalog.

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Do evolved stars in the LMC show dual dust chemistry?

E. Marini1,2, F. Dell’Agli3,4, D.A. García–Hernández3,4, M.A.T. Groenewegen5, S. Puccetti6, P. Ventura2 and E. Villaver7

1Dipartimento di Matematica e Fisica, Università degli Studi Roma Tre, via della Vasca Navale 84, 00100, Roma, Italy
2INAF, Osservatorio Astronomico di Roma, Via Frascati 33, 00077, Monte Porzio Catone, Italy
3Instituto de Astrofísica de Canarias (IAC), E-38200 La Laguna, Tenerife, Spain
4Departamento de Astrofísica, Universidad de La Laguna (ULL), E-38206 La Laguna, Tenerife, Spain
5Koninklijke Sterrenwacht van België, Ringlaan 3, 1180 Brussels, Belgium
6ASI, Via del Politecnico, 00133 Roma, Italy
7Departamento de Física Teórica, Universidad Autónoma de Madrid, Cantoblanco 28049 Madrid, Spain

We study a group of evolved M-stars in the Large Magellanic Cloud, characterized by a peculiar spectral energy distribution. While the 9.7-μm feature arises from silicate particles, the whole infrared data seem to suggest the presence of an additional featureless dust species. We propose that the circumstellar envelopes of these sources are characterized by a dual dust chemistry, with an internal region, harbouring carbonaceous particles, and an external

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zone, populated by silicate, iron and alumina dust grains. Based on the comparison with results from stellar modelling that describe the dust formation process, we deduce that these stars descend from low-mass \((M < 2 \, M_\odot)\) objects, formed 1–4 Gyr ago, currently evolving either in the post-AGB phase or through an after-pulse phase, when the shell CNO nuclear activity is temporarily extinguished. Possible observations able to confirm or disregard the present hypothesis are discussed.

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\[ \text{Awakening of the fast-spinning accreting Be/X-ray pulsar A 0538–66} \]

L. Ducci\(^1\), S. Mereghetti\(^2\) and A. Santangelo\(^1\)

\(^1\)Institut für Astronomie und Astrophysik, Kepler Center for Astro and Particle Physics, Eberhard Karls Universität, Sand 1, 72076 Tübingen, Germany

\(^2\)INAF – Istituto di Astrofisica Spaziale e Fisica Cosmica, Via A. Corti 12, 20133 Milano, Italy

A 0538–66 is a Be/X-ray binary (Be/XRB) hosting a 69-ms pulsar. It emitted bright X-ray outbursts with peak luminosity up to \(\sim 10^{39} \text{ erg s}^{-1}\) during the first years after its discovery in 1977. Since then, it was always seen in quiescence or during outbursts with \(L_X \lesssim 4 \times 10^{37} \text{ erg s}^{-1}\). In 2018 we carried out XMM–Newton observations of A 0538–66 during three consecutive orbits when the pulsar was close to periastron. In the first two observations we discovered a remarkable variability, with flares of typical durations between \(2–50 \text{ s}\) and peak luminosities up to \(\sim 4 \times 10^{38} \text{ erg s}^{-1}\) \((0.2–10 \text{ keV})\). Between the flares the luminosity was \(\sim 2 \times 10^{35} \text{ erg s}^{-1}\). The flares were absent in the third observation, during which A 0538–66 had a steady luminosity of \(2 \times 10^{34} \text{ erg s}^{-1}\). In all observations, the X-ray spectra consist of a softer component, well described by an absorbed power law with photon index \(\Gamma_1 \approx 2–4\) and \(N_H \approx 10^{21} \text{ cm}^{-2}\), plus a harder power-law component \((\Gamma_2 \approx 0–0.5)\) dominating above \(\sim 2 \text{ keV}\). The softer component shows larger flux variations than the harder one, and a moderate hardening correlated with the luminosity. The fast flaring activity seen in these observations was never observed before in A 0538–66, nor, to our best knowledge, in other Be/XRBs. We explore the possibility that during our observations the source was accreting in a regime of nearly spherically symmetric inflow. In this case, an atmosphere can form around the neutron star magnetosphere and the observed variability can be explained by transitions between the accretion and supersonic propeller regimes.

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\[ \text{The Magellanic System: the puzzle of the leading gas stream} \]

Thor Tepper-García\(^1,2\), Joss Bland-Hawthorn\(^1,2\), Marcel S. Pawlowski\(^3,4\) and Tobias K. Fritz\(^5,6\)

\(^1\)Sydney Institute for Astronomy, School of Physics, University of Sydney, NSW 2006, Australia

\(^2\)ARC Centre of Excellence for All Sky Astrophysics in Three Dimensions (ASTRO-3D), Australia

\(^3\)Department of Physics and Astronomy, University of California, Irvine, CA 92697, USA

\(^4\)Leibniz-Institut für Astrophysik Potsdam (AIP), An der Sternwarte 16, D-14482 Potsdam, Germany

\(^5\)Instituto de Astrofísica de Canarias, Calle Via Láctea s/n, E-38206 La Laguna, Tenerife, Spain

\(^6\)Universidad de La Laguna. Avda. Astrofísico Fco. Sánchez s/n, E-38200 La Laguna, Tenerife, Spain

The Magellanic Clouds (MCs) are the most massive gas-bearing systems falling into the Galaxy at the present epoch. They show clear signs of interaction, manifested in particular by the Magellanic Stream, a spectacular gaseous wake that trails from the MCs extending more than 150 deg across the sky. Ahead of the MCs is the “Leading Arm” usually interpreted as the tidal counterpart of the Magellanic Stream, an assumption we now call into question. We revisit the formation of these gaseous structures in a first-infall scenario, including for the first time a Galactic model with a weakly magnetized, spinning hot corona. In agreement with previous studies, we recover the location and the
extension of the Stream on the sky. In contrast, we find that the formation of the Leading Arm – that is otherwise present in models without a corona – is inhibited by the hydrodynamic interaction with the hot component. These results hold with or without coronal rotation or a weak, ambient magnetic field. Since the existence of the hot corona is well established, we are led to two possible interpretations: (i) the Leading Arm survives because the coronal density beyond 20 kpc is a factor > 10 lower than required by conventional spheroidal coronal X-ray models, in line with recent claims of rapid coronal rotation; or (ii) the “Leading Arm” is cool gas trailing from a ‘frontrunner’, a satellite moving ahead of the MCs, consistent with its higher metallicity compared to the trailing stream. Both scenarios raise issues that we discuss.

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Dust destruction in non-radiative shocks
H. Zhu\textsuperscript{1,2}, P. Slane\textsuperscript{2}, J. Raymond\textsuperscript{2} and W. W. Tian\textsuperscript{1,3}

\textsuperscript{1}Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China
\textsuperscript{2}Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
\textsuperscript{3}School of Astronomy and Space Science, University of Chinese Academy of Sciences, Beijing 100049, China

Supernova remnant (SNR) shock waves are the main place where interstellar dust grains are destroyed. However, the dust destruction efficiency in non-radiative shocks is still not well known. One way to estimate the fraction of dust destroyed is to compare the difference between postshock gas abundances and preshock medium total abundances when the preshock elemental depletion factors are known. We compare the postshock gas abundances of 16 SNRs in Large Magellanic Cloud (LMC) with the LMC interstellar medium abundances that we derived based on 69 slow-rotating early B-type stars. We find that, on average, \( \sim 61\% \) of Si rich dust grains are destroyed in the shock while the fraction of dust destroyed is only \( \sim 40\% \) for Fe rich dust grains. This result supports the idea that the high depletion of Fe in the diffuse neutral medium is not caused by the resilience of Fe rich grains but because of faster growth rate. This work also presents a potential way to constrain the chemical composition of interstellar dust.

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An updated SMC and Magellanic Bridge catalog of star clusters, associations and related objects
Eduardo Bica\textsuperscript{1}, Pieter Westera\textsuperscript{2}, Leandro de O. Kerber\textsuperscript{3,4}, Bruno Dias\textsuperscript{5,6}, Francisco Maia\textsuperscript{4}, João F. C. Santos Jr.\textsuperscript{7} and Beatriz Barbuy\textsuperscript{4}

\textsuperscript{1}Universidade Federal do Rio Grande do Sul, Instituto de Física, Av. Bento Gonçalves 9500, 91501-970, Porto Alegre, Brazil
\textsuperscript{2}Universidade Federal do ABC, Centro de Ciências Naturais e Humanas, Av. dos Estados 5001, 09210-580, Santo André, Brazil
\textsuperscript{3}Universidade Estadual de Santa Cruz, Depto. de Ciências Exatas e Tecnológicas, Rod. Jorge Amado km 16, 45662-900, Ilhéus, Brazil
\textsuperscript{4}Universidade de São Paulo, Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Rua do Matão 1226, 05508-090, São Paulo, Brazil
\textsuperscript{5}European Southern Observatory, Alonso de Córdova 3107, Vitacura, Santiago, Chile
\textsuperscript{6}Universidad Andrés Bello, Facultad de Ciencias Exactas, Departamento de Física, Av. Fernandez Concha 700, Las Condes, Santiago, Chile
\textsuperscript{7}Universidade Federal de Minas Gerais, Departamento de Física, ICEX, Av. Antonio Carlos 6627, 31270-901 Belo Horizonte, MG, Brazil

We present a catalog of star clusters, associations and related extended objects in the Small Magellanic Cloud and the Magellanic Bridge with 2741 entries, a factor 2 more than a previous version a decade ago. It implements data from the literature up till December 2018. The analysis was carried out with digital atlases in various bands currently
available in Aladin. In particular, we cross-identified recent cluster samples from the VMC, OGLE IV and SMASH surveys, confirming new clusters and pointing out equivalencies. A major contribution of the present catalog are accurate central positions for clusters and small associations, including a new sample of 47 clusters or candidates in the SMC and 19 in the Bridge. We also analysed the recent SMC catalog by Bitsakis and collaborators who detected objects with an overdensity search algorithm. They refer to them as clusters, but most have low stellar density, are extended and diffuse, so that we classified them as associations. We conclude that they found 1173 new objects, whereas 119 have equivalency in the literature. A general catalog must also deal with the recent discoveries of 27 faint and ultra-faint star clusters and galaxies projected on the far surroundings of the Clouds, mostly with DES. They have been complemented with photometric, spectroscopic and kinematical follow-ups. The underluminous galaxies around the Magellanic System, still too few compared to Λ Cold Dark Matter simulations, can bring constraints to galaxy formation and hierarchical evolution. On the other hand, we provide diagnostics, when possible, for the nature of the ultra-faint clusters, searching for benchmarks and frontiers of the Magellanic System extensions into the Milky Way potential.

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Long-period variables in the Gaia era

Nami Mowlavi1,2, Michele Trabucchi3 and Thomas Lebzelter4

1Department of Astronomy, University of Geneva, Ch. des Maillettes 51, 1290 Versoix, Switzerland
2Department of Astronomy, Beijing Normal University, 19 XinJieKouWai St., HaiDian District, 100875 Beijing, China
3Dipartimento di Fisica e Astronomia Galileo Galilei Università di Padova, Vicolo dell’Osservatorio 3, 35122 Padova, Italy
4Department of Astrophysics, University of Vienna, Türkenschanz-strasse 17, 1180 Vienna, Austria

The second Gaia data release (DR2, spring 2018) included a unique all-sky catalogue of large-amplitude long-period variables (LPVs) containing Miras and semi-regular variables. These stars are on the Asymptotic Giant Branch (AGB), and are characterized by high luminosity, changing surface composition, and intense mass loss, that make them of paramount importance for stellar, Galactic, and extra-galactic studies.

An initial investigation of LPVs in the Large Magellanic Cloud (LMC) from the DR2 catalog of LPVs has revealed the possibility to disentangle O-rich and C-rich stars using a combination of optical Gaia and infrared 2MASS photometry. The so-called Gaia–2MASS diagram constructed to achieve this has further been shown to enable the identification of sub-groups of AGB stars among the O-rich and C-rich LPVs.

Here, we extend this initial study of the Gaia–2MASS diagram to the Small Magellanic Cloud and the Galaxy, and use a variability amplitude proxy to identify LPVs from the full Gaia DR2 archive. We show that the remarkable properties found in the LMC also apply to these other stellar systems. Interesting features, moreover, emerge as a result of the different metallicities between the three stellar environments, which we highlight in this exploratory presentation of Gaia’s potential to study stellar populations harboring LPVs.

Finally, we look ahead to the future, and highlight the power of the exploitation of Gaia RP spectra for the identification of carbon stars using solely Gaia data in forthcoming data releases, as revealed in an Image of the Week published by the Gaia consortium on the European Space Agency’s web site.

These proceedings include three animated images that can be used as outreach material.

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