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# THE MAGELLANIC CLOUDS NEWSLETTER

*An electronic publication dedicated to the Magellanic Clouds, and astrophysical phenomena therein*

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Editor: Jacco van Loon

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## *Editorial*

Dear Colleagues,

It is my pleasure to present you the 180<sup>th</sup> issue of the Magellanic Clouds Newsletter.

There is a fantastic collection of new results to look at, as well as the announcement of an IAU Symposium at the end of the newsletter.

You're invited to post research updates, requests for data or collaborations, et cetera, as well as pretty pictures, historical anecdotes... the sky isn't even a limit.

The next issue is planned to be distributed on the 1<sup>st</sup> of February 2023. Wishing you a happy change of year and reasons for optimism.

Editorially Yours,  
Jacco van Loon

## The VISCACHA survey – V. Rejuvenating three faint SMC clusters

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We present the analysis of three faint clusters of the Small Magellanic Cloud RZ 82, HW 42, and RZ 158. We employed the SOAR telescope instrument SAM with adaptive optics, allowing us to reach to  $V \sim 23$ – $24$  mag, unprecedentedly, a depth sufficient to measure ages of up to about 10–12 Gyr. All three clusters are resolved to their centres, and the resulting colour–magnitude diagrams (CMDs) allow us to derive ages of 3.9, 2.6, and 4.8 Gyr, respectively. These results are significantly younger than previous determinations (7.1, 5.0, and 8.3 Gyr, respectively), based on integrated photometry or shallower CMDs. We rule out older ages for these clusters based on deep photometry and statistical isochrone fitting. We also estimate metallicities for the three clusters of  $[\text{Fe}/\text{H}] = -0.68$ ,  $-0.57$ , and  $-0.90$ , respectively. These updated ages and metallicities are in good agreement with the age–metallicity relation for the bulk of SMC clusters. Total cluster masses ranging from  $\sim 7$ – $11 \cdot 10^3 M_{\odot}$  were estimated from integrated flux, consistent with masses estimated for other SMC clusters of similar ages. These results reduce the number of SMC clusters known to be older than about 5 Gyr and highlight the need of deep and spatially resolved photometry to determine accurate ages for older low-luminosity SMC star clusters.

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Available from <https://arxiv.org/abs/2209.05532>

and from <https://academic.oup.com/mnrasl/article-abstract/517/1/L41/6701629>

## Near-infrared spectroscopy of embedded protostars in the massive metal-poor star-forming region NGC 346

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We present medium-resolution ( $R \sim 4000$ ) YJ-, H-, and K-band spectroscopy of candidate young stellar objects (YSOs) in NGC 346, the most active star-formation region in the metal-poor ( $Z = 1/5 Z_{\odot}$ ) Small Magellanic Cloud.

The spectra were obtained with the KMOS (K-Band Multi-Object Spectrograph) integral field instrument on the Very Large Telescope. From our initial sample of 18 candidate high-mass YSOs previously identified from mid-IR photometry and radiative transfer model fits to their spectral energy distributions, approximately half were resolved into multiple components by our integral-field data. In total, we detect 30 continuum sources and extract reliable spectra for 12 of these objects. The spectra show various features including hydrogen recombination lines, and lines from H<sub>2</sub>, He I, and [Fe II], which are indicative of accretion, discs, and outflowing material in massive YSOs. We spectroscopically confirm the youthful nature of nine YSO candidates, and identify two others as OB stars. All of the confirmed YSOs have Br $\gamma$  in emission, but no emission is seen from the CO bandhead, despite other disc tracers present in the spectra. He I 1.083  $\mu$ m emission is also detected at appreciably higher rates than for the Galaxy.

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## Classical OBe stars as post-supernova runaways: confirming binary origins

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Massive binaries play an important role in fields ranging from gravitational-wave astronomy to stellar evolution. We provide several lines of evidence that classical OBe stars in the Small Magellanic Cloud (SMC) obtain their rapid rotation from mass and angular momentum transfer in massive binaries, which predicts that the subsequent supernovæ should often eject OBe stars into the field. We find that (1) OBe stars have a higher field frequency than OB stars; (2) our cumulative distribution function (CDF) of stellar distances from O stars shows that OBe stars are indeed much more isolated than ordinary OB stars of corresponding spectral types; (3) the CDFs of OBe stars approach that of high-mass X-ray binaries (HMXBs), which are confirmed post-supernova objects; and (4) Oe stars are as isolated from clusters as Be stars, implying that their final masses are relatively independent of their initial masses, consistent with major mass transfer. Lastly, we also find that the spatial distribution of supergiant OBe stars differs from that of classical OBe stars, consistent with the different mechanisms responsible for their emission-line spectra.

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# Timing six energetic rotation-powered X-ray pulsars, including the fast-spinning young PSR J0058–7218 and Big Glitcher PSR J0537–6910

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Measuring a pulsar’s rotational evolution is crucial to understanding the nature of the pulsar. Here we provide updated timing models for the rotational evolution of six pulsars, five of which are rotation phase-connected using primarily NICER X-ray data. For the newly-discovered fast energetic young pulsar, PSR J0058–7218, we increase the baseline of its timing model from 1.4 days to 8 months and not only measure more precisely its spin-down rate  $\dot{\nu} = (-6.2324 \pm 0.0001) \times 10^{-11} \text{ Hz s}^{-1}$  but also for the first time the second time derivative of spin rate  $\ddot{\nu} = (4.2 \pm 0.2) \times 10^{-21} \text{ Hz s}^{-2}$ . For the fastest and most energetic young pulsar, PSR J0537–6910 (with 16 ms spin period), we detect 4 more glitches, for a total of 15 glitches over 4.5 years of NICER monitoring, and show that its spin-down behavior continues to set this pulsar apart from all others, including a long-term braking index  $n = -1.234 \pm 0.009$  and interglitch braking indices that asymptote to  $\lesssim 7$  for long times after a glitch. For PSR J1101–6101, we measure a much more accurate spin-down rate that agrees with a previous value measured without phase-connection. For PSR J1412+7922 (also known as Calvera), we extend the baseline of its timing model from our previous 1-year model to 4.4 years, and for PSR J1849–0001, we extend the baseline from 1.5 years to 4.7 years. We also present a long-term timing model of the energetic pulsar, PSR J1813–1749, by fitting previous radio and X-ray spin frequencies from 2009–2019 and new ones measured here using 2018 NuSTAR and 2021 *Chandra* data.

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## Stellar age determination in the mass–luminosity plane

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The ages of stars have historically relied on isochrone fitting of standardised grids of models. While these stellar models have provided key constraints on observational samples of massive stars, they inherit many systematic uncertainties, mainly in the internal mixing mechanisms applied throughout the grid, fundamentally undermining the isochrone method. In this work, we utilise the M–L plane of Higgins & Vink as a method of determining stellar age, with

mixing-corrected models applying a calibrated core overshooting  $\alpha_{\text{ov}}$  and rotation rate to fit the observational data. We provide multiple test-beds to showcase our new method, while also providing comparisons to the commonly-used isochrone method, highlighting the dominant systematic errors. We reproduce the evolution of individual O stars, and analyse the wider sample of O and B supergiants from the VLT-FLAMES Tarantula Survey, providing dedicated models with estimates for  $\alpha_{\text{ov}}$ ,  $\Omega/\Omega_{\text{crit}}$ , and ultimately stellar ages. The M–L plane highlights a large discrepancy in the spectroscopic masses of the O supergiant sample. Furthermore the M–L plane also demonstrates that the evolutionary masses of the B supergiant sample are inappropriate. Finally, we utilise detached eclipsing binaries, VFTS 642 and VFTS 500, and present their ages resulting from their precise dynamical masses, offering an opportunity to constrain their interior mixing. For the near-TAMS system, VFTS 500, we find that both components require a large amount of core overshooting ( $\alpha_{\text{ov}} \sim 0.5$ ), implying an extended main-sequence width. We hence infer that the vast majority of B supergiants are still burning hydrogen in their cores.

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## Physical properties of the supernova remnant population in the Small Magellanic Cloud

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The X-ray emission from a supernova remnant is a powerful diagnostic of the state of its shocked plasma. The temperature and the emission measure are related to the energy of the explosion, the age of the remnant, and the density of the surrounding medium. Here we present the results of a study of the remnant population of the Small Magellanic Cloud. Progress in X-ray observations of remnants has resulted in a sample of 20 remnants in the Small Magellanic Cloud with measured temperatures and emission measures. We apply spherically symmetric supernova remnant evolution models to this set of remnants to estimate ages, explosion energies, and circumstellar medium densities. The distribution of ages yields a remnant birth rate of  $\sim 1/1200$  yr. The energies and densities are well fit with log-normal distributions, with means of  $1.6 \times 10^{51}$  erg and  $0.14 \text{ cm}^{-3}$ , and  $1\sigma$  dispersions of a factor of 1.87 in energy and 3.06 in density, respectively.

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## SMC – Last mosaic images

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We present mosaic images of the Small Magellanic Cloud (SMC) observed with the Spitzer IRAC 3.6  $\mu\text{m}$  and 4.5  $\mu\text{m}$  bands over two epochs, 2017 August 25 to 2017 September 13, and 2017 November 24 to 2018 February 12. The survey region comprises  $\sim 30$  square degrees covering the SMC and the Bridge to the Large Magellanic Cloud. The region is covered by 52  $\sim 1^\circ.1 \times 1^\circ.1$  tiles, with each tile including images in each band for both separate and combined epochs. The mosaics are made in individual tangent projections in J2000 coordinates. The angular pixel size is  $0''.6$  with a resolution (FWHM) of  $\sim 2''.0$ . We describe processing to correct or mitigate residual artifacts and remove background discontinuities. The mosaic images are publicly available at the Infrared Science Archive (IRSA).

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# Additional evidence for a pulsar wind nebula in the heart of SN 1987A from multiepoch X-ray data and MHD modeling

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Since the day of its explosion, supernova (SN) 1987A has been closely monitored to study its evolution and to detect its central compact relic. In fact, the formation of a neutron star is strongly supported by the detection of neutrinos from the SN. However, besides the detection in the Atacama Large Millimeter/submillimeter Array (ALMA) data of a feature that is compatible with the emission arising from a protopulsar wind nebula (PWN), the only hint of the existence of such an elusive compact object is provided by the detection of hard emission in NuSTAR data up to  $\sim 20$  keV. We report on the simultaneous analysis of multiepoch observations of SN 1987A performed with *Chandra*, *XMM-Newton*, and NuSTAR. We also compare the observations with a state-of-the-art three-dimensional magnetohydrodynamic simulation of SN 1987A. A heavily absorbed power law, consistent with the emission from a PWN embedded in the heart of SN 1987A, is needed to properly describe the high-energy part of the observed spectra. The spectral parameters of the best-fit power law are in agreement with the previous estimate, and exclude diffusive shock acceleration as a possible mechanism responsible for the observed non-thermal emission. The information extracted from our analysis is used to infer the physical characteristics of the pulsar and the broadband emission from its nebula, in agreement with the ALMA data. Analysis of the synthetic spectra also shows that, in the near future, the main contribution to the Fe K emission line will originate in the outermost shocked ejecta of SN 1987A.

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## A study of photoionized gas in two H II regions of the N 44 complex in the LMC using MUSE observations

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We use the optical integral field observations with Multi-Unit Spectroscopic Explorer (MUSE) on the Very Large Telescope, together with CLOUDY photoionization models to study ionization structure and physical conditions of two luminous H II regions in N 44 star-forming complex of the Large Magellanic Cloud. The spectral maps of various

emission lines reveal a stratified ionization geometry in N 44 D1. The spatial distribution of [O I] 6300Å emission in N 44 D1 indicates a partially covered ionization front at the outer boundary of the H II region. These observations reveal that N 44 D1 is a Blister H II region. The [O I] 6300Å emission in N 44 C does not provide a well-defined ionization front at the boundary, while patches of [S II] 6717Å and [O I] 6300Å emission bars are found in the interior. The results of spatially resolved MUSE spectra are tested with the photoionization models for the first time in these H II regions. A spherically symmetric ionization-bounded model with a partial covering factor, which is appropriate for a Blister H II region can well reproduce the observed geometry and most of the diagnostic line ratios in N 44 D1. Similarly, in N 44 C we apply a low density and optically thin model based on the observational signatures. Our modeling results show that the ionization structure and physical conditions of N 44 D1 are mainly determined by the radiation from an O5 V star. However, local X-rays, possibly from supernovæ or stellar wind, play a key role. In N 44 C, the main contribution is from three ionizing stars.

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## Discovery of PSR J0523–7125 as a circularly polarized variable radio source in the Large Magellanic Cloud

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We report the discovery of a highly circularly polarized, variable, steep-spectrum pulsar in the Australian Square

Kilometre Array Pathfinder (ASKAP) Variables and Slow Transients (VAST) survey. The pulsar is located about  $1^\circ$  from the center of the Large Magellanic Cloud, and has a significant fractional circular polarization of  $\sim 20\%$ . We discovered pulsations with a period of 322.5 ms, dispersion measure (DM) of  $157.5 \text{ pc cm}^{-3}$ , and rotation measure (RM) of  $+456 \text{ rad m}^{-2}$  using observations from the MeerKAT and the Parkes telescopes. This DM firmly places the source, PSR J0523–7125, in the Large Magellanic Cloud (LMC). This RM is extreme compared to other pulsars in the LMC (more than twice that of the largest previously reported one). The average flux density of  $\sim 1 \text{ mJy}$  at 1400 MHz and  $\sim 25 \text{ mJy}$  at 400 MHz places it among the most luminous radio pulsars known. It likely evaded previous discovery because of its very steep radio spectrum (spectral index  $\alpha \approx -3$ , where  $S_\nu \propto \nu^\alpha$ ) and broad pulse profile (duty cycle  $\gtrsim 35\%$ ). We discuss implications for searches for unusual radio sources in continuum images, as well as extragalactic pulsars in the Magellanic Clouds and beyond. Our result highlighted the possibility of identifying pulsars, especially extreme pulsars, from radio continuum images. Future large-scale radio surveys will give us an unprecedented opportunity to discover more pulsars and potentially the most distant pulsars beyond the Magellanic Clouds.

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and from <https://iopscience.iop.org/article/10.3847/1538-4357/ac61dc>

## An improved calibration of the wavelength dependence of metallicity on the Cepheid Leavitt law

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The Cepheid period–luminosity (PL) relation (or Leavitt law) has served as the first rung of the most widely used extragalactic distance ladder and is central to the determination of the local value of the Hubble constant ( $H_0$ ). We investigate the influence of metallicity on Cepheid brightness, a term that significantly improves the overall fit of the distance ladder, to better define its wavelength dependence. To this aim, we compare the PL relations obtained for three Cepheid samples having distinct chemical composition (in the Milky Way and Magellanic Clouds) and focusing on the use of improved and recent data while covering a metallicity range of about 1 dex. We estimate the metallicity effect (hereafter  $\gamma$ ) in 15 filters from mid-IR to optical wavelengths, including five Wesenheit indices, and we derive a significant metallicity term in all filters, in agreement with recent empirical studies and models, in the sense of metal-rich Cepheids being brighter than metal-poor ones. We describe the contribution of various systematic effects in the determination of the  $\gamma$  term. We find no evidence of  $\gamma$  changing over the wavelength range 0.5–4.5  $\mu\text{m}$ , indicating that the main influence of metallicity on Cepheids is in their luminosity rather than color. Finally, we identify factors that sharpen the empirical constraints on the metallicity term over past studies, including corrections for the depth of the Magellanic Clouds, better-calibrated Cepheid photometry, improved Milky Way extinction estimates, and revised and expanded metallicity measurements in the LMC.

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and from <https://iopscience.iop.org/article/10.3847/1538-4357/ac97e2>

# Rotation measure structure functions with higher-order stencils as a probe of small-scale magnetic fluctuations and its application to the Small and Large Magellanic Clouds

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Magnetic fields and turbulence are important components of the interstellar medium (ISM) of star-forming galaxies. It is challenging to measure the properties of the small-scale ISM magnetic fields (magnetic fields at scales smaller than the turbulence driving scale). Using numerical simulations, we demonstrate how the second-order rotation measure (RM, which depends on thermal electron density,  $n_e$ , and magnetic field,  $b$ ) structure function can probe the properties of small-scale  $b$ . We then apply our results to observations of the Small and Large Magellanic Clouds (SMC and LMC). First, using Gaussian random  $b$ , we show that the characteristic scale where the RM structure function flattens is approximately equal to the correlation length of  $b$ . We also show that computing the RM structure function with a higher-order stencil (more than the commonly-used two-point stencil) is necessary to accurately estimate the slope of the structure function. Then, using Gaussian random  $b$  and lognormal  $n_e$  with known power spectra, we derive an empirical relationship between the slope of the power spectrum of  $b$ ,  $n_e$ , and RM. We apply these results to the SMC and LMC and estimate the following properties of small-scale  $b$ : correlation length ( $160 \pm 21$  pc for the SMC and  $87 \pm 17$  pc for the LMC), strength ( $14 \pm 2$   $\mu\text{G}$  for the SMC and  $15 \pm 3$   $\mu\text{G}$  for the LMC), and slope of the magnetic power spectrum ( $-1.3 \pm 0.4$  for the SMC and  $-1.6 \pm 0.1$  for the LMC). We also find that  $n_e$  is practically constant over the estimated  $b$  correlation scales.

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# The properties of fast yellow pulsating supergiants: FYPS point the way to missing red supergiants

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Fast yellow pulsating supergiants (FYPS) are a recently-discovered class of evolved massive pulsator. As candidate post-red supergiant objects, and one of the few classes of pulsating evolved massive stars, these objects have incredible potential to change our understanding of the structure and evolution of massive stars. Here we examine the lightcurves of a sample of 126 cool supergiants in the Magellanic Clouds observed by the Transiting Exoplanet Survey Satellite (TESS) in order to identify pulsating stars. After making quality cuts and filtering out contaminant objects, we examine the distribution of pulsating stars in the Hertzsprung–Russell (HR) diagram, and find that FYPS occupy a region above  $\log L/L_\odot \gtrsim 5.0$ . This luminosity boundary corresponds to stars with initial masses of  $\sim 18\text{--}20 M_\odot$ , consistent with the most massive red supergiant progenitors of supernovae (SNe) II-P, as well as the observed properties of SNe IIb progenitors. This threshold is in agreement with the picture that FYPS are post-RSG stars. Finally, we characterize the behavior of FYPS pulsations as a function of their location in the HR diagram. We find low frequency pulsations at higher effective temperatures, higher frequency pulsations at lower temperatures, with a transition between the two behaviors at intermediate temperatures. The observed properties of FYPS make them fascinating objects for future theoretical study.

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# Lessons from the Magellanic System and its modeling

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The prominent Magellanic Stream that dominates the HI sky provides a tantalizing number of observations that potentially constrains the Magellanic Clouds and the Milky Way (MW) outskirts. Here we show that the "ram-pressure plus collision" model naturally explain these properties, and is able to predict some of the most recent observations made after the model was made. These include the complexity of the stellar populations in the Magellanic Bridge, for which kinematics, ages, and distances are well measured, and the Northern Tidal Arm, for which the model predicts its formation from the MW tidal forces. It appears that this over-constrained model provides a good path to investigate the Stream properties. This contrasts with tidal models that reproduce only half of the Stream's main properties, in particular a tidal tail cannot reproduce the observed inter-twisted filaments, and its gas content is not sufficiently massive to provide the large amount of HI and HII gas associated to the Stream. Despite the efforts made to reproduce the large amounts of gas brought by the Clouds, it seems that no viable solution for the tidal model could be foreseen. Since the "ram-pressure plus collision" model has not succeeded for a Large Magellanic Cloud mass above  $2 \times 10^{10} M_{\odot}$ , we conjecture that a low mass is required to form the Stream.

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and from <https://academic.oup.com/mnras/article/515/1/940/6609508>

## An updated metal-dependent theoretical scenario for classical Cepheids

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To properly quantify the possible residual systematic errors affecting the classical Cepheid distance scale, a detailed theoretical scenario is recommended. By extending the set of nonlinear, convective pulsation models published for  $Z = 0.02$  to  $Z = 0.004$ ,  $Z = 0.008$ , and  $Z = 0.03$ , we provide a detailed homogeneous, non-linear model grid taking into account simultaneous variations of the mass–luminosity relation, the efficiency of super-adiabatic convection, and the chemical composition. The dependence of the inferred period–radius, period–mass–radius, and period–mass–luminosity–temperature relations on the input parameters is discussed for both the fundamental and first overtone modes. The trend of the instability strip getting redder as the metallicity increases is confirmed for the additional mass–luminosity assumptions and mixing length values. From the obtained multi-filter light curves, we derive the mean magnitudes and colors, and in turn the period–luminosity–color and period–Wesenheit relations, for each assumed chemical composition, mass–luminosity relation, and efficiency of super-adiabatic convection. Application to a well-studied sample of Cepheids in the Large Magellanic Cloud allows us to constrain the dependence of the inferred distance modulus on the assumed mass–luminosity relation, and the inclusion of the metallicity term in the derivation of the period–Wesenheit relations allows us, for each assumed mass–luminosity relation, to predict the metallicity dependence of the Cepheid distance scale. The obtained metal-dependent, period–Wesenheit relations are compared with recent results in the literature and applied to a sample of Gaia Early Data Release 3 Galactic Cepheids with known metal abundances to derive individual parallaxes. The comparison of these predictions with Gaia results is finally discussed.

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Available from <https://arxiv.org/abs/2206.11154>

# Unveiling polarized emission from interstellar dust of the Large Magellanic Cloud with *Planck*

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Polarization of interstellar dust emission is a powerful probe of dust properties and magnetic field structure. Yet studies of external galaxies are hampered by foreground dust contribution. The study aims at separating the polarised signal from the Large Magellanic Cloud (LMC) from that of the Milky Way (MW) to construct a wide-field, spatially complete map of dust polarization using the *Planck* 353 GHz data. To estimate the foreground polarization direction, we used velocity gradients in HI spectral line data and assessed the performance of the output by comparing it to starlight extinction polarization. We estimate the foreground intensity using the dust-to-gas correlation and the average intensity around the LMC and we assume the foreground polarization to be uniform and equal to the average of the MW around the galaxy to derive foreground  $I$ ,  $Q$ , and  $U$  parameters. After foreground removal, the geometry of the plane-of-the-sky magnetic field tends to follow the structure of the atomic gas. This is notably the case along the molecular ridges extending south and south-east of the 30 Doradus star-forming complex and along the more diffuse southern arm extending towards the Small Magellanic Cloud. There is also an alignment between the magnetic field and the outer arm in the western part. The median polarization fraction in the LMC is slightly lower than that observed for the MW as well as the anti-correlation between the polarization angle dispersion function and the polarization fraction. Overall, polarization fraction distribution is similar to that observed in the MW.

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## Monitoring observations of SMC X-1’s excursions (MOOSE) – I. Programme description and initial high-state spectral results

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SMC X-1 has exhibited three superorbital period excursions since the onset of X-ray monitoring beginning with the *Rossi* X-ray Timing Explorer’s launch in 1995. The Neutron star Interior Composition Explorer has recently probed a fourth observed excursion beginning in 2021 with our programme monitoring observations of SMC X-1’s excursions (MOOSE). These sensitive new MOOSE data probe different super-orbital periods and phases within them. Spectral fits to the high-state continuum during 2021 April to 2022 January show that the intrinsic spectral shapes are characterized by a soft ( $kT \sim 0.19$  keV) disc component and a hard ( $\Gamma \sim 0.7$ ) power-law tail. When the 2021–2022 NICER observations, taken during an excursion, are compared to 2016 XMM–*Newton* observations (outside of an excursion), we find little evidence for intrinsic spectral variability across the high states, but find evidence for a  $> 3\sigma$  change in the absorption, although we caution that there may be calibration differences between the two instruments. Thus, over different lengths of super-orbital periods, we see little evidence for intrinsic spectral changes in the high state. Upcoming studies of the pulse profiles may shed light on the mechanism behind the excursions.

**Published in Monthly Notices of the Royal Astronomical Society**

Available from <https://arxiv.org/abs/2206.06558>

# Ca II triplet spectroscopy of Small Magellanic Cloud red giants – VI Analysis of chemical properties of the main body

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*Aims:* In this paper we analyze the chemical evolution of the main body of the SMC, adding six additional clusters to previously published samples, based on homogeneously determined and accurate metallicities.

*Methods:* We derived radial velocities and Ca II Triplet (CaT) metallicity of more than 150 red giants stars in six SMC star clusters and their surrounding fields, with the instrument GMOS on Gemini-S. The mean cluster radial velocity and metallicity were obtained with mean errors of  $2.2 \text{ km s}^{-1}$  and 0.03 dex, while the mean field metallicities have a mean error of 0.13 dex. We add this information to that available for another 51 clusters and 30 fields with CaT metallicities on the same scale. Using this expanded sample we analyze the chemical properties of the SMC main body, defined as the inner  $3^\circ 4$  in semi-major axis.

*Results:* We found a high probability that the metallicity distribution of the main body clusters is bimodal with a metal-rich and a metal-poor cluster group, having mean metallicities with a dispersion of  $\mu = -0.80$ ,  $\sigma = 0.06$  and  $\mu = -1.15$ ,  $\sigma = 0.10$  dex, respectively. On the other hand, main body field stars show a unimodal metallicity distribution peaking at  $[\text{Fe}/\text{H}] \sim -1$  and dispersion of 0.3. Neither metal-rich nor metal-poor clusters present a metallicity gradient. However, the full main body cluster sample and field stars have a negative metallicity gradient consistent with each other, but the one corresponding to clusters has a large error due to the large metallicity dispersion present in the clusters studied in that region. Metal-rich clusters present a clear age–metallicity relation, while metal-poor clusters present no chemical enrichment throughout the life of the galaxy.

*Conclusions:* We present observational evidence that the chemical enrichment is complex in the SMC main body. Two cluster groups with potential different origins could be coexisting in the main body. More data with precise and homogeneous metallicities and distances are needed and dynamical simulations are required to understand the possible different origins for the two cluster groups.

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and from <https://www.aanda.org/articles/aa/pdf/2022/08/aa43762-22.pdf>

## *Announcement*

### **IAU Symposium 384: Planetary Nebulæ: a Universal Toolbox in the Era of Precision Astrophysics**

IAU Symposium 384: Planetary Nebulæ: a Universal Toolbox in the Era of Precision Astrophysics Kraków, Poland, September 4–8, 2023

#### **FIRST ANNOUNCEMENT**

We are pleased to announce the upcoming International Astronomical Union Symposium 384 "Planetary Nebulæ: a Universal Toolbox in the Era of Precision Astrophysics". You can now pre-register here to receive future updates. Full registration and abstract submission is expected to open in December 2022 with deadlines for abstract submission and grant application on March 31<sup>st</sup>, 2023.

#### **Meeting information**

Dates: September 4–8, 2023

Location: Collegium Novum of the Jagiellonian University, Gołębia 24 Str, 31-007 Kraków, Poland

Website: <https://iaus384-pne.ncac.torun.pl/>

Mode: primarily in-person, but remote participation will be possible

Workshop fee: 250 Euros for full participants, 150 Euros for students

Registration opens: December 2022

Abstract deadline: March 31<sup>st</sup>, 2023

Proceedings: electronic version included in the registration fee; hardcopy 50 GBP in addition

#### **Conference rationale**

Planetary nebulae trace the end phase of the life of low-mass and intermediate-mass stars, at the crossroads of stellar and galactic evolution. They result from AGB mass loss, itself a poorly understood process. The bright nebulae are significant drivers of the chemical evolution of galaxies: they are the dominant source of carbon in the modern Universe, a significant source of nitrogen, and a source of half of all elements heavier than iron. The beautiful nebular shapes have led to in-depth hydrodynamics studies with applicability in many fields. The central stars contain a large population of close binaries, which connects planetary nebulae to the developing field of transients. Outreach, publicity and education have made significant use of planetary nebulae.

Planetary nebula populations have been observed at distances of tens of Mpc, where the underlying lower-mass stars themselves are undetectable. They are the only stars (other than supernovae) whose individual spectra can be measured out to the distance of the Coma cluster. They allow one to measure the velocities of stars at large distances from the centers of galaxies where the dark matter dominates, and they trace the assembly of diffuse light in clusters of galaxies.

#### **Objectives:**

Planetary nebulae exist at the interface of stellar and galactic evolution studies. The symposium aims to develop the connections between these different areas, and to put the research of planetary nebulae into the context of modern, integrated astrophysics. For more information, registration and important deadlines see the Website <https://iaus384-pne.ncac.torun.pl/>

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*See also* <https://iaus384-pne.ncac.torun.pl/>