Dear Colleagues,

It is my pleasure to present you the 136th issue of the Magellanic Clouds Newsletter.

I’m off to the IAU General Assembly now – hope to see some of you there!.

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

Editorially Yours,
Jacco van Loon
The VLT-FLAMES Tarantula Survey XXII. Multiplicity properties of the B-type stars


We investigate the multiplicity properties of 408 B-type stars observed in the 30 Doradus region of the Large Magellanic Cloud with multi-epoch spectroscopy from the VLT-FLAMES Tarantula Survey (VFTS). We use a cross-correlation method to estimate relative radial velocities from the helium and metal absorption lines for each of our targets. Objects with significant radial-velocity variations (and with an amplitude larger than $16 \text{ km s}^{-1}$) are classified as spectroscopic binaries. We find an observed spectroscopic binary fraction ($f_{B}(\text{obs})$) of $0.25 \pm 0.02$, which appears constant across the field of view, except for the two older clusters (Hodge 301 and SL 639). These two clusters have significantly lower binary fractions of $0.08 \pm 0.08$ and $0.10 \pm 0.09$, respectively. Using synthetic populations and a model of our observed epochs and their potential biases, we constrain the intrinsic multiplicity properties of the dwarf and giant (i.e. relatively unevolved) B-type stars in 30 Dor. We obtain a present-day binary fraction $f_{B}(\text{true}) = 0.58 \pm 0.11$, with a flat period distribution. Within the uncertainties, the multiplicity properties of the B-type stars agree with those for the O stars in 30 Dor from the VFTS.

Accepted for publication in A&A
Available from arXiv:1505.07121

The Araucaria project: The first-overtone classical Cepheid in the eclipsing system OGLE-LMC-CEP-2532


We present here the first spectroscopic and photometric analysis of the double-lined eclipsing binary containing the classical, first-overtone Cepheid OGLE-LMC-CEP-2532 (MACHO 81.8997.87). The system has an orbital period of 800 days and the Cepheid is pulsating with a period of 2.035 days. Using spectroscopic data from three high-class telescopes and photometry from three surveys spanning 7500 days we
are able to derive the dynamical masses for both stars with an accuracy better than 3%. This makes the Cepheid in this system one of a few classical Cepheids with an accurate dynamical mass determination ($M_1 = 3.90 \pm 0.10 M_\odot$). The companion is probably slightly less massive ($3.82 \pm 0.10 M_\odot$), but may have the same mass within errors ($M_2/M_1 = 0.981 \pm 0.015$). The system has an age of about 185 million years and the Cepheid is in a more advanced evolutionary stage.

For the first time precise parameters are derived for both stars in this system. Due to the lack of the secondary eclipse for many years not much was known about the Cepheid’s companion. In our analysis we used extra information from the pulsations and the orbital solution from the radial velocity curve. The best model predicts a grazing secondary eclipse shallower than 1 mmag, hence undetectable in the data, about 370 days after the primary eclipse.

The dynamical mass obtained here is the most accurate known for a first-overtone Cepheid and will contribute to the solution of the Cepheid mass discrepancy problem.

Available from arXiv:1504.04611

Kepler’s Supernova: an overluminous Type Ia event interacting with a massive circumstellar medium at a very late phase

Satoru Katsuda$^1$, Koji Mor2, Keiichi Maeda$^{3,4}$, Masaoori Tanaka$^5$, Katsujir Koyanag$^{6,7}$, Hiroshi Tsunemi$^8$, Hiroshi Nakajim$^8$, Yoshitomo Maeda$^1$, Masanobu Ozaki$^3$ and Robert Petre$^8$

1Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA), Japan
2University of Miyazaki, Japan
3Department of Astronomy, Kyoto University, Japan
4Kavli Institute for the Physics and Mathematics of the Universe (WPI), University of Tokyo, Japan
5National Astronomical Observatory of Japan, Japan
6Osaka University, Japan
7Department of Physics, Kyoto University, Japan
8NASA Goddard Space Flight Center, USA

We have analyzed XMM-Newton, Chandra, and Suzaku observations of Kepler’s supernova remnant (SNR) to investigate the properties of both the SN ejecta and the circumstellar medium (CSM). For comparison, we have also analyzed two similarly-aged, ejecta-dominated SNRs: Tycho’s SNR, thought to be the remnant of a typical Type Ia SN, and SNR 0509−67.5 in the Large Magellanic Cloud, thought to be the remnant of an overluminous (SN 1991T-like) Type Ia SN. By simply comparing the X-ray spectra, we find that line intensity ratios of iron-group elements (IGE) to intermediate-mass elements (IME) for Kepler’s SNR and SNR 0509−67.5 are much higher than those for Tycho’s SNR. We therefore argue that Kepler’s SNR is the product of an overluminous Type Ia event.

We find that the CSM component in Kepler’s SNR consists of tenuous diffuse gas ($\sim 0.3 M_\odot$) present throughout the entire remnant, plus dense knots ($\sim 0.035 M_\odot$). Both of these components have an elevated N abundance ($N/H \sim 4$ times the solar value), suggesting that they originate from CNO-processed material from the progenitor system. The mass of the diffuse CSM allows us to infer the pre-SN mass-loss rate of the system to be $\sim 1.5 \times 10^{-5} (v_w/10 \text{ km s}^{-1}) M_\odot$ yr$^{-1}$, in general agreement with results from recent hydrodynamical simulations. The dense knots have slow optical proper motions as well as relatively small X-ray-measured ionization timescales, which indicates that they were located a few pc away from the progenitor system and were only recently heated by forward shocks. Therefore, we argue that Kepler’s SN was an overluminous (91T-like) event that started to interact with massive CSM a few hundred years after the explosion. This supports the possible link between 91T-like SNe and the so-called “Ia-CSM” SNe – a rare class of SNe Ia associated with massive CSM. The link implies that $\sim 10\%$ of SNe Ia are associated with massive CSM which most likely originates from a companion star in a single degenerate progenitor system.

Accepted for publication in The Astrophysical Journal
Available from arXiv:1506.03135

3
Spectral variations of Of?p oblique magnetic rotator candidates in the Magellanic Clouds


STScI, USA
LCO, Chile
ULg, Belgium
RMC, Canada
Armagh Obs., Northern Ireland
Univ. La Serena, Chile
CSIC–INT A, Spain
UCL, England
ROE, Scotland
CSIC, Spain

Optical spectroscopic monitoring has been conducted of two O stars in the Small and one in the Large Magellanic Cloud, the spectral characteristics of which place them in the Of?p category, which has been established in the Galaxy to consist of oblique magnetic rotators. All of these Magellanic stars show systematic spectral variations typical of the Of?p class, further strengthening their magnetic candidacy to the point of virtual certainty. The spectral variations are related to photometric variations derived from OGLE data by Naze et al. (2015) in a parallel study, which yields rotational periods for two of them. Now circular spectropolarimetry is required to measure their fields, and ultraviolet spectroscopy to further characterize their low-metallicity, magnetically confined winds, in support of hydrodynamical analyses.

Accepted for publication in AJ
Available from arXiv:1507.02434

First detection of HCO+ absorption in the Magellanic System


Department of Astronomy, University of Wisconsin – Madison, WI 53706, USA
Research School for Astronomy & Astrophysics, Mount Stromlo Observatory, Cotter Road, Weston Creek, ACT 2611, Australia
Department of Astronomy, Columbia University, New York, NY 10027, USA
National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903-2475, USA
Department of Astronomy, University of Illinois, 1002 West Green Street, Urbana, IL 61801, USA
Institut für Physik und Astronomie, Universität Potsdam, Karl-Liebknecht-Straße 24/25, 14476 Potsdam-Golm, Germany
Leibniz-Institut für Astrophysik Potsdam (AIP), An der Sternwarte 16, 14482 Potsdam, Germany
Department of Physics and Astronomy and MQ Research Centre in Astronomy, Astrophysics and Astrophotonics, Macquarie University, NSW 2109, Australia
CSIRO Astronomy and Space Science, P.O. Box 76, Epping, NSW 1710, Australia
University of Tasmania, School of Maths and Physics, Private Bag 37, Hobart, TAS 7001, Australia

We present the first detection of HCO+ absorption in the Magellanic System. Using the ATCA, we observed nine extragalactic radio continuum sources behind the Magellanic System and detected HCO+ absorption towards one source located behind the leading edge of the Magellanic Bridge. The detection is located at an LSR velocity of $v = 214.0 \pm 0.4$ km s$^{-1}$, with a FWHM of $\Delta v = 4.5 \pm 1.0$ km s$^{-1}$ and an optical depth of $\tau$(HCO+) = 0.10 \pm 0.02. Although there is abundant neutral hydrogen (H I) surrounding the sight line in position–velocity space, at the exact location of the absorber the H I column density is low, $< 10^{20}$ cm$^{-2}$, and there is little evidence for dust or CO emission from Planck observations. While the origin and survival of molecules in such a diffuse environment remain unclear, dynamical events such as H I flows and cloud collisions in this interacting system likely play an important role.

Available from arXiv:1506.03333
Wolf–Rayet stars in the Small Magellanic Cloud: I. Analysis of the single WN stars


Institut für Physik und Astronomie, Universität Potsdam, Karl-Liebknecht-Str. 24/25, D-14476 Potsdam, Germany
Charité, Humboldt-Universität zu Berlin, Charitéplatz 1, D-10117 Berlin, Germany

Wolf–Rayet (WR) stars have a severe impact on their environments owing to their strong ionizing radiation fields and powerful stellar winds. Since these winds are considered to be driven by radiation pressure, it is theoretically expected that the degree of the wind mass-loss depends on the initial metallicity of WR stars. Following our comprehensive studies of WR stars in the Milky Way, M 31, and the LMC, we derive stellar parameters and mass-loss rates for all seven putatively single WN stars known in the SMC. Based on these data, we discuss the impact of a low-metallicity environment on the mass loss and evolution of WR stars. The quantitative analysis of the WN stars is performed with the Potsdam Wolf–Rayet (PoWR) model atmosphere code. The physical properties of our program stars are obtained from fitting synthetic spectra to multi-band observations. In all SMC WN stars, a considerable surface hydrogen abundance is detectable. The majority of these objects have stellar temperatures exceeding 75 kK, while their luminosities range from $10^{5.5}$ to $10^{6.1} \ L_\odot$. The WN stars in the SMC exhibit on average lower mass-loss rates and weaker winds than their counterparts in the Milky Way, M 31, and the LMC. By comparing the mass-loss rates derived for WN stars in different Local Group galaxies, we conclude that a clear dependence of the wind mass-loss on the initial metallicity is evident, supporting the current paradigm that WR winds are driven by radiation. A metallicity effect on the evolution of massive stars is obvious from the HRD positions of the SMC WN stars at high temperatures and high luminosities. Standard evolution tracks are not able to reproduce these parameters and the observed surface hydrogen abundances. Homogeneous evolution might provide a better explanation for their evolutionary past.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:1507.04000

Catalogue of Be/X-ray binary systems in the Small Magellanic Cloud: X-ray, optical & IR properties

M.J. Coe and J. Kirk

Physics & Astronomy, University of Southampton, UK

This is a catalogue of approximately 70 X-ray emitting binary systems in the Small Magellanic Cloud (SMC) that contain a Be star as the mass donor in the system and a clear X-ray pulse signature from a neutron star. The systems are generally referred to as Be/Xray binaries. It lists all their known binary characteristics (orbital period, eccentricity), the measured spin period of the compact object, plus the characteristics of the Be star (spectral type, size of the circumstellar disk, evidence for NRP behaviour). For the first time data from the Spitzer Space Telescope are combined with ground-based data to provide a view of these systems out into the far-IR. Many of the observational parameters are presented as statistical distributions and compared to other similar similar populations (e.g., isolated Be & B stars) in the SMC, and to other Be/X-ray systems in the Milky Way. In addition previous important results are re-investigated using this excellently homogeneous sample. In particular, the evidence for a bi-modality in the spin period distribution is shown to be even stronger than first proposed, and the correlation between orbital period and circumstellar disk size seen in galactic sources is shown to be clearly present in the SMC systems and quantised for the first time.

Published in MNRAS
Available from arXiv:1506.01920
and from http://www.southampton.ac.uk/~mjcoe/smc/
Period–luminosity relations derived from the OGLE-III fundamental mode Cepheids. II: The Small Magellanic Cloud Cepheids

Chow-Choong Ngeow\(^1\), Shashi M. Kanbur\(^2\), Anupam Bhardwaj\(^3\) and Harinder P. Singh\(^3\)

\(^1\)Graduate Institute of Astronomy, National Central University, Taiwan
\(^2\)Department of Physics, SUNY Oswego, USA
\(^3\)Department of Physics & Astrophysics, University of Delhi, India

In this paper we present multi-band period–luminosity (P–L) relations for fundamental mode Cepheids in the SMC. The optical VI-band mean magnitudes for these SMC Cepheids were taken from the third phase of the Optical Gravitational Lensing Experiment (OGLE-III) catalog. We also matched the OGLE-III SMC Cepheids to 2MASS and SAGE-SMC catalog to derive mean magnitudes in the JHK-bands and the four Spitzer IRAC bands, respectively. All photometry was corrected for extinction by adopting the Zaritsky’s extinction map. Cepheids with periods smaller than \(\sim 2.5\) days were removed from the sample. In addition to the extinction corrected P–L relations in nine filters from optical to infrared, we also derived the extinction-free Wesenheit function for these Cepheids. We tested the nonlinearity of these SMC P–L relations (except the 8.0-\(\mu\)m-band P–L relation) at 10 days: none of the P–L relations show statistically significant evidence of nonlinearity. When compared to the P–L relations in the LMC, the \(t\)-test results revealed that there is a difference between the SMC/LMC P–L slopes only in the V- and J-band. Further, we found excellent agreement between the SMC/LMC Wesenheit P–L slope. The difference in LMC and SMC Period–Wesenheit relation LMC and SMC zero points was found to be \(\Delta \mu = 0.483 \pm 0.015\) mag. This amounts to a difference in distance modulus between the LMC and SMC.

Published in Astrophysical Journal
Available from arXiv:1507.03185

The origin of dust extinction curves with or without the 2175 Å bump in galaxies: the case of the Magellanic Clouds

Kenji Bekki\(^1\), Hiroyuki Hirashita\(^2\) and Takuji Tsujimoto\(^3\)

\(^1\)ICRAR (UWA), Australia
\(^2\)Institute of Astronomy, Academia Sinica, Taiwan
\(^3\)NAOJ, Japan

The Large and Small Magellanic Clouds (LMC and SMC, respectively) are observed to have characteristic dust extinction curves that are quite different from those of the Galaxy (e.g., strength of the 2175 Å bump). Although the dust composition and size distribution of the Magellanic Clouds (MCs) that can self-consistently explain their observed extinction curves have been already proposed, it remain unclear whether and how the required dust properties can be achieved in the formation histories of the MCs. We therefore investigate the time evolution of the dust properties of the MCs and thereby derive their extinction curves using one-zone chemical evolution models with formation and evolution of small and large silicate and carbonaceous dust grains and dusty winds associated with starburst events. We find that the observed SMC extinction curve without a conspicuous 2175 Å bump can be reproduced well by our SMC model, if the small carbon grains can be selectively lost through the dust wind during the latest starburst about 0.2 Gyr ago. We also find that the LMC extinction curve with a weak 2175 Å bump can be reproduced by our LMC model with less efficient removal of dust through dust wind. We discuss possible physical reasons for different dust wind efficiencies between silicate and graphite and among galaxies.

Accepted for publication in ApJ
Available from arXiv:150703327
The VLT-FLAMES Tarantula Survey. XXI. Stellar spin rates of O-type spectroscopic binaries

O.H. Ramírez-Aguadero 1, H. Sana 2, S.E. de Mink 1, V. Hénault-Brunet 3, A. de Koter 1,4, N. Langer 5, F. Tramper 1, G. Gräfener 6, C.J. Evans 7, J.S. Vink 8, P.L. Dufton 8 and W.D. Taylor 2

1 Anton Pannekoek Institute, University of Amsterdam, The Netherlands
2 ESA/Space Telescope Science Institute, USA
3 Department of Physics, University of Surrey, England
4 Instituut voor Sterrenkunde, Universiteit Leuven, Belgium
5 Argelander-Institute für Astronomie, Universität Bonn, Germany
6 Armagh Observatory, Northern Ireland
7 UK Astronomy Technology Centre, Scotland
8 Astrophysics Research Center, University of Belfast, Northern Ireland

The initial distribution of spin rates of massive stars is a fingerprint of their elusive formation process. It also sets a key initial condition for stellar evolution and is thus an important ingredient in stellar population synthesis. So far, most studies have focused on single stars. Most O stars are however found in multiple systems. By establishing the spin-rate distribution of a sizeable sample of O-type spectroscopic binaries and by comparing the distributions of binary sub-populations with one another as well as with that of presumed single stars in the same region, we aim to constrain the initial spin distribution of O stars in binaries, and to identify signatures of the physical mechanisms that affect the evolution of the massive stars spin rates. We use ground-based optical spectroscopy obtained in the framework of the VLT-FLAMES Tarantula Survey (VFTS) to establish the projected equatorial rotational velocities (v sin i) for components of 114 spectroscopic binaries in 30 Doradus. The v sin i values are derived from the full-width at half-maximum (FWHM) of a set of spectral lines, using a FWHM vs. v sin i calibration that we derive based on previous line analysis methods applied to single O-type stars in the VFTS sample. The overall v sin i distribution of the primary stars resembles that of single O-type stars in the VFTS, featuring a low-velocity peak (at v sin i < 200 km s\(^{-1}\)) and a shoulder at intermediate velocities (200 < v sin i < 300 km s\(^{-1}\)). The distributions of binaries and single stars however differ in two ways. First, the main peak at v sin i ~ 100 km s\(^{-1}\) and a shoulder at intermediate velocities (200 < v sin i < 300 km s\(^{-1}\)) is broader and slightly shifted toward higher spin rates in the binary distribution compared to that of the presumed-single stars. Second, the v sin i distribution of primaries lacks a significant population of stars spinning faster than 300 km s\(^{-1}\) while such a population is clearly present in the single star sample. The v sin i distribution of binaries with amplitudes of radial velocity variation in the range of 20 to 200 km s\(^{-1}\) is similar to that of single O stars below v sin i < 170 km s\(^{-1}\). Our results are compatible with the assumption that binary components formed with the same spin distribution as single stars, and that this distribution contains few or no fast-spinning stars. The higher average spin rate of stars in short-period binaries may either be explained by spin-up through tides in such tight binary systems, or by spin-down of a fraction of the presumed-single stars and long-period binaries through magnetic braking (or by a combination of both mechanisms). Most primaries and secondaries of SB2 systems with P orb < 10 d appear to have similar rotational velocities. This is in agreement with tidal locking in close binaries where the components have similar radii. The lack of very rapidly spinning stars among binary systems supports the idea that most stars with v sin i > 300 km s\(^{-1}\) in the single-star sample are actually spun-up post-binary interaction products. Finally, the overall similarities (low-velocity peak and intermediate-velocity shoulder) of the spin distribution of binary and single stars argue for a massive star formation process in which the initial spin is set independently of whether stars are formed as single stars or as components of a binary system.

Accepted for publication in Astronomy & Astrophysics
Available from arXiv:1507.02286

Dust cooling in supernova remnants in the Large Magellanic Cloud

Ji Yeon Seok 1,2, Bon-Chul Koo 3 and Hiroyuki Hirashita 2

1 Department of Physics and Astronomy, University of Missouri, Columbia, MO 65211, USA
2 Institute for Astronomy and Astrophysics, Academia Sinica, P.O. Box 23-141, Taipei 10617, Taiwan
3 Department of Physics and Astronomy, Seoul National University, Seoul 151-742, South Korea

The infrared-to-X-ray (IRX) flux ratio traces the relative importance of dust cooling to gas cooling in astrophysical
plasma such as supernova remnants (SNRs). We derive IRX ratios of SNRs in the LMC using Spitzer and Chandra SNR survey data and compare them with those of Galactic SNRs. IRX ratios of all the SNRs in the sample are found to be moderately greater than unity, indicating that dust grains are a more efficient coolant than gas although gas cooling may not be negligible. The IRX ratios of the LMC SNRs are systematically lower than those of the Galactic SNRs. As both dust cooling and gas cooling pertain to the properties of the interstellar medium, the lower IRX ratios of the LMC SNRs may reflect the characteristics of the LMC, and the lower dust-to-gas ratio (a quarter of the Galactic value) is likely to be the most significant factor. The observed IRX ratios are compared with theoretical predictions that yield IRX ratios an order of magnitude larger. This discrepancy may originate from the dearth of dust in the remnants due to either the local variation of the dust abundance in the preshock medium with respect to the canonical abundance or the dust destruction in the postshock medium. The non-equilibrium ionization cooling of hot gas, in particular for young SNRs, may also cause the discrepancy. Finally, we discuss implications for the dominant cooling mechanism of SNRs in low-metallicity galaxies.

Published in The Astrophysical Journal
Available from arXiv:1506.07926

Velocity resolved $[\text{C}\ II]$, $[\text{C}\ I]$, and CO observations of the N 159 star-forming region in the Large Magellanic Cloud: a complex velocity structure and variation of the column densities

Yoko Okada$^1$, Miguel Angel Requena-Torres$^2$, Rolf Güsten$^2$, Jürgen Stutzki$^3$, Helmut Wiesemeyer$^2$, Patrick Pütz$^3$ and Oliver Ricken$^2$

1I. Physikalisches Institut der Universität zu Köln, Germany
2Max-Planck-Institut für Radioastronomie, Germany
3Max-Planck-Institut für Radioastronomie, Germany

Context: The $[\text{C}\ II] 158$-$\mu$m fine structure line is one of the dominant cooling lines in star-forming active regions. Together with models of photon-dominated regions, the data is used to constrain the physical properties of the emitting regions, such as the density and the radiation field strength. According to the modeling, the $[\text{C}\ II] 158$-$\mu$m line integrated intensity compared to the CO emission is expected to be stronger in lower metallicity environments owing to lower dust shielding of the UV radiation, a trend that is also shown by spectral-unresolved observations. In the commonly assumed clumpy UV-penetrated cloud scenario, the models predict a $[\text{C}\ II]$ line profile similar to that of CO. However, recent spectral-resolved observations with Herschel/HIFI and SOFIA/GREAT (as well as the observations presented here) show that the velocity resolved line profile of the $[\text{C}\ II]$ emission is often very different from that of CO lines, indicating a more complex origin of the line emission including the dynamics of the source region.

Aims: The Large Magellanic Cloud (LMC) provides an excellent opportunity to study in great detail the physics of the interstellar medium (ISM) in a low-metallicity environment by spatially resolving individual star-forming regions. The aim of our study is to investigate the physical properties of the star-forming ISM in the LMC by separating the origin of the emission lines spatially and spectrally. In this paper, we focus on the spectral characteristics and the origin of the emission lines, and the phases of carbon-bearing species in the N 159 star-forming region in the LMC.

Methods: We mapped a $4' \times (3'-4')$ region in N 159 in $[\text{C}\ II]158\mu m$ and $[\text{N}\ II]205\mu m$ with the GREAT instrument on board SOFIA. We also observed CO(3–2), (4–3), (6–5), $^{13}\text{CO}(3–2)$, and $[\text{C}\ I]^{3}P_{1}–^{3}P_{0}$ and $^{3}P_{2}–^{3}P_{1}$ with APEX. All spectra are velocity resolved.

Results: The emission of all transitions observed shows a large variation in the line profiles across the map and in particular between the different species. At most positions the $[\text{C}\ I]$ emission line profile is substantially wider than that of CO and $[\text{C}\ II]$. We estimated the fraction of the $[\text{C}\ II]$ integrated line emission that cannot be fitted by the CO line profile to be 20% around the CO cores, and up to 50% at the area between the cores, indicating a gas component that has a much larger velocity dispersion than the ones probed by the CO and $[\text{C}\ I]$ emission. We derived the relative contribution from $C^{+}$, $C$, and CO to the column density in each velocity bin. The result clearly shows that the contribution from $C^{+}$ dominates the velocity range far from the velocities traced by the dense molecular gas. Spatially, the region located between the CO cores of N 159 W and E has a higher fraction of $C^{+}$ over the whole velocity range. We estimate the contribution of the ionized gas to the $[\text{C}\ II]$ emission using the ratio to the $[\text{N}\ II]$
emission, and find that the ionized gas contributes $\leq 19\%$ to the $[\text{C} \text{II}]$ emission at its peak position, and $\leq 15\%$ over the whole observed region. Using the integrated line intensities, we present the spatial distribution of $I_{[\text{C} \text{II}]} / I_{\text{FIR}}$.

**Conclusions:** This study demonstrates that the $[\text{C} \text{II}]$ emission in the LMC N 159 region shows significantly different velocity profiles from that of CO and $[\text{C} \text{I}]$ emissions, emphasizing the importance of velocity resolved observations in order to distinguish different cloud components.

**Accepted for publication in Astronomy & Astrophysics**

**Available from arXiv:1506.01860**

---

**HST astrometry in the 30 Doradus region: measuring proper motions of individual stars in the Large Magellanic Cloud**

I. Platais$^1$, R.P. van der Marel$^2$, D.J. Lennon$^{2,3}$, J. Anderson$^2$, A. Bellini$^2$, E. Sabbi$^2$, H. Sana$^2$ and L.R. Bedin$^4$

$^1$JHU, USA  
$^2$STScI, USA  
$^3$ESAC, Spain  
$^4$INAF–OAPd, Italy

We present measurements of positions and relative proper motions in the 30 Doradus region of the Large Magellanic Cloud (LMC). We detail the construction of a single-epoch astrometric reference frame, based on specially-designed observations obtained with the two main imaging instruments ACS/WFC and WFC3/UVIS onboard the *Hubble* Space Telescope (HST). Internal comparisons indicate a sub milli-arcsecond (mas) precision in the positions and the presence of semi-periodic systematics with a mean amplitude of $\sim 0.8$ mas. We combined these observations with numerous archival images taken with WFPC2 and spanning 17 years. The precision of the resulting proper motions for well-measured stars around the massive cluster R 136 can be as good as $\sim 20$ micro-arcsec yr$^{-1}$, although the true accuracy of proper motions is generally lower due to the residual systematic errors. The observed proper-motion dispersion for our highest-quality measurements is $\sim 0.1$ mas yr$^{-1}$. Our catalog of positions and proper motions contains 86,590 stars down to $V \sim 25$ mag and over a total area of $\sim 70$ square arcmin. We examined the proper motions of 105 relatively bright stars and identified a total of 6 candidate runaway stars. We are able to tentatively confirm the runaway status of star VFTS 285, consistent with the findings from line-of-sight velocities, and to show that this star has likely been ejected from R 136. This study demonstrates that with HST it is now possible to reliably measure proper motions of individual stars in the nearest dwarf galaxies such as the LMC.

**Accepted for publication in AJ**

**Available from arXiv:1507.06653**

---

**Identification of a class of low-mass Asymptotic Giant Branch stars struggling to become carbon stars in the Magellanic Clouds**

Martha L. Boyer$^1$, Iain McDonald$^2$, Sundar Srinivasan$^3$, Albert Zijlstra$^2$, Jacco Th. van Loon$^4$, Knut A.G. Olsen$^5$ and George Sonneborn$^1$

$^1$NASA Goddard Space Flight Center, USA  
$^2$Jodrell Bank Centre for Astrophysics, University of Manchester, UK  
$^3$Institute for Astronomy & Astrophysics, Academia Sinica, Taiwan  
$^4$Lennard-Jones Laboratories, Keele University, UK  
$^5$National Optical Astronomy Observatory, USA

We have identified a new class of Asymptotic Giant Branch (AGB) stars in the Small and Large Magellanic Clouds (SMC/LMC) using optical to infrared photometry, light curves, and optical spectroscopy. The strong dust production and long-period pulsations of these stars indicate that they are at the very end of their AGB evolution. Period–mass–radius relations for the fundamental-mode pulsators give median current stellar masses of 1.14 M$_{\odot}$ in the LMC and
0.94 M\(_\odot\) in the SMC (with dispersions of 0.21 and 0.18 M\(_\odot\), respectively), and models suggest initial masses of < 1.5 M\(_\odot\) and < 1.25 M\(_\odot\), respectively. This new class of stars includes both O-rich and C-rich chemistries, placing the limit where dredge-up allows carbon star production below these masses. A high fraction of the brightest among them should show S star characteristics indicative of atmospheric C/O \(\sim 1\), and many will form O-rich dust prior to their C-rich phase. These stars can be separated from their less-evolved counterparts by their characteristically red J–[8] colors.

Accepted for publication in ApJ
Available from arXiv:1507.07003

Matter mixing in core-collapse supernova ejecta: large density perturbations in the progenitor star?

Jirong Mao\(^{1,2,5,6}\), Masaomi Ono\(^2\), Shigehiro Nagataki\(^1\), Masa-aki Hashimoto\(^2\), Hirotaka Ito\(^1\), Jin Matsumoto\(^1\), Maria G. Dainotti\(^{1,3}\) and Shiu-Hang Lee\(^{1,4}\)

\(^{1}\)RIKEN, Japan
\(^{2}\)Kyushu University, Japan
\(^{3}\)Jagiellonian University, Poland
\(^{4}\)JAXA, Japan
\(^{5}\)Yunnan Observatory, China
\(^{6}\)Key Laboratory for the Structure and Evolution of Celestial Objects of Chinese Academy of Sciences, China

Matter mixing is one important topic in the study of core-collapse supernova (CCSN) explosions. In this paper, we perform two-dimensional hydrodynamic simulations to reproduce the high velocity \(^{56}\)Ni clumps observed in SN 1987A. This is the first time that large density perturbation is proposed in the CCSN progenitor to generate Rayleigh–Taylor (RT) instability and make the effective matter mixing. In the case of a spherical explosion, RT instability is efficient at both (C+O)/He and He/H interfaces of the SN progenitor. Radial coherent structures shown in perturbation patterns are important for obtaining high velocity \(^{56}\)Ni clumps. We can also obtain matter mixing features and high velocity \(^{56}\)Ni clumps in some cases of aspherical explosion. We find that one of the most favorable models in our work has a combination of bipolar and equatorially asymmetric explosions in which at least 25% of density perturbation is introduced at different composition interfaces of the CCSN progenitor. These simulation results are comparable to the observational findings of SN 1987A.

Accepted for publication in ApJ
Available from arXiv:1507.07061

Apparent age spreads in clusters and the role of stellar rotation

F. Niederhofer\(^{1,2}\), C. Georgy\(^3\), N. Bastian\(^4\) and S. Ekström\(^5\)

\(^{1}\)Excellence Cluster, Munich, Germany
\(^{2}\)LMU, Germany
\(^{3}\)Keele, UK
\(^{4}\)LJMU, UK
\(^{5}\)Geneva, Switzerland

We use the Geneva SYCLIST isochrone models that include the effects of stellar rotation to investigate the role that rotation has on the resulting colour–magnitude diagram (CMD) of young and intermediate age clusters. We find that if a distribution of rotation velocities exists within the clusters, rotating stars will remain on the main sequence (MS) for longer, appearing to be younger than non-rotating stars within the same cluster. This results in an extended main sequence turn-off (eMSTO) that appears at young ages (~ 30 Myr) and lasts beyond 1 Gyr. If this eMSTO
Bridge over troubled gas: clusters and associations under the SMC and LMC tidal stresses

Eduardo Bica\textsuperscript{1}, Basílio Santiago\textsuperscript{1}, Charles Bonatto\textsuperscript{1}, Rafael Garcia-Dias\textsuperscript{3}, Leandro Kerber\textsuperscript{2}, Bruno Dias\textsuperscript{3,4}, Beatriz Barbay\textsuperscript{1} and Eduardo Balbinot\textsuperscript{5}

\textsuperscript{1}Depto. de Astronomia, Instituto de Física, Universidade Federal do Rio Grande do Sul, Porto Alegre/RS, Brazil
\textsuperscript{2}LA TO–DCET, Universidade Estadual de Santa Cruz, Ilhéus/BA, Brazil
\textsuperscript{3}IAG, Universidade de São Paulo, São Paulo/SP, Brazil
\textsuperscript{4}Department of Physics, Durham University, Durham, UK
\textsuperscript{5}Department of Physics, University of Surrey, Guildford, UK

We obtained SOAR telescope B and V photometry of 14 star clusters and 2 associations in the Bridge tidal structure connecting the LMC and SMC. These objects are used to study the formation and evolution of star clusters and associations under tidal stresses from the Clouds. Typical star clusters in the Bridge are not richly populated and have in general relatively large diameters ($\approx 30$–$35$pc), being larger than Galactic counterparts of similar age. Ages and other fundamental parameters are determined with field-star decontaminated photometry. A self-consistent approach is used to derive parameters for the most-populated sample cluster NGC 796 and two young CMD templates built with the remaining Bridge clusters. We find that the clusters are not coeval in the Bridge. They range from approximately a few Myr (still related to optical H\textsc{ii} regions and WISE and Spitzer dust emission measurements) to about 100–200 Myr. The derived distance moduli for the Bridge objects ($1^h56^m < \alpha < 2^h28^m$) suggests that the Bridge is a structure connecting the LMC far-side in the East to the foreground of the SMC to the West. Most of the present clusters are part of the tidal dwarf candidate D 1, which is associated with an H\textsc{i} overdensity. We find further evidence that the studied part of the Bridge is evolving into a tidal dwarf galaxy, decoupling from the Bridge.

Accepted for publication in MNRAS
Available from arXiv:1507.07725
nearby galaxies. We end by examining our new survey for WR stars in the Magellanic Clouds, which has revealed a new type of WN star, never before seen.

Oral contribution, published in Potsdam Wolf–Rayet Workshop
Available from arXiv:1507.07297

The discovery and physical parameterization of a new type of Wolf–Rayet star

Kathryn F. Neugent¹, Philip Massey¹, D. John Hillier² and Nidia Morrell³

¹Lowell Observatory, USA
²University of Pittsburgh, USA
³Las Campanas Observatory, Chile

As part of our ongoing Wolf–Rayet (WR) Magellanic Cloud survey, we have discovered 13 new WRs. However, the most exciting outcome of our survey is not the number of new WRs, but their unique characteristics. Eight of our discoveries appear to belong to an entirely new class of WRs. While one might naively classify these stars as WN3+O3 V binaries, such a pairing is unlikely. Preliminary cmfgen modeling suggests physical parameters similar to early-type WNs in the Large Magellanic Cloud except with mass-loss rates three to five times lower and slightly higher temperatures. The evolution status of these stars remains an open question.

Oral contribution, published in Potsdam Wolf–Rayet Workshop
Available from arXiv:1507.07154

Neutrinos from SN 1987A – a puzzle revisited

Gerd Schatz¹, ²

¹Heidelberg University, Germany
²Karlsruhe Institute of Technology, Germany

The smallest of the four detectors which claim to have observed neutrinos from SN 1987A registered the events more than 4 h earlier than the other three ones. This claim is not usually accepted because it is difficult to understand that the other (and larger) detectors did not register any events at the same time. It is shown that microlensing of the neutrinos by a star in-between the supernova (SN) and Earth can enhance the neutrino intensity at the position of one detector by more than an order of magnitude with respect to the other detectors. Such a configuration is improbable but not impossible. Essential for this enhancement is the small source diameter, of order 100 km. So if two bursts of neutrinos were emitted by SN 1987A at a separation of about 4 h it could be explained easily that the smallest detector observed the first burst while the other ones missed it and vice versa.

Poster contribution, published in ”24th European Cosmic Ray Symposium”, Kiel, 2014
Available from arXiv:1507.07107
Dust in the Local Group

Aigen Li¹, Shu Wang², Jian Gao² and B.W. Jiang²

¹Department of Physics and Astronomy, University of Missouri, Columbia, MO 65211, USA
²Department of Astronomy, Beijing Normal University, Beijing 100875, China

How dust absorbs and scatters starlight as a function of wavelength (known as the interstellar extinction curve) is crucial for correcting for the effects of dust extinction in inferring the true luminosity and colors of reddened astrophysical objects. Together with the extinction spectral features, the extinction curve contains important information about the dust size distribution and composition. This review summarizes our current knowledge of the dust extinction of the Milky Way, three Local Group galaxies (i.e. the Small and Large Magellanic Clouds, and M 31), and galaxies beyond the Local Group.

Published in “Lessons from the Local Group” – a conference in honour of David Block and Bruce Elmegreen, eds. K.C. Freeman, B.G. Elmegreen, D.L. Block & M. Woolway (Springer: New York), p85
Available from arXiv:1507.06604