Dear Colleagues, friends,

It is my pleasure to present you the 127th issue of the Magellanic Clouds Newsletter.

It’s been a little quieter, blame the holidays, bless you. Other distractions of life, perhaps. No worries: The Clouds will be up there for a while still. Plenty on supernova remnants though, and evolved stars and their remnants in general.

Check out a fantastic opportunity to work with an inspiring scientist in an amazing team at the Space Telescope Science Institute!

The next issue is planned to be distributed on the 1st of April. Have an intense but safe 2014.

Editorially Yours,
Jacco van Loon
Optical spectra of 5 new Be/X-ray Binaries in the Small Magellanic Cloud and the link of the supergiant B[e] star LHA 115-S 18 with an X-ray source

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The Small Magellanic Cloud (SMC) is well known to harbor a large number of High-Mass X-ray Binaries (HMXBs). The identification of their optical counterparts provides information on the nature of the donor stars and can help to constrain the parameters of these systems and their evolution. We obtained optical spectra for a number of HMXBs identified in previous Chandra and XMM–Newton surveys of the SMC using the AAΩ/2dF fiber-fed spectrograph at the Anglo–Australian Telescope. We find 5 new Be/X-ray binaries (BeXRBs; including a tentative one), by identifying the spectral type of their optical counterparts, and we confirm the spectral classification of an additional 15 known BeXRBs. We compared the spectral types, orbital periods, and eccentricities of the BeXRB populations in the SMC and the Milky Way and we find marginal evidence for difference between the spectral type distributions, but no statistically significant differences for the orbital periods and the eccentricities. Moreover, our search revealed that the well-known supergiant B[e] star LHA 115-S 18 (or AzV 154) is associated with the weak X-ray source CXOU J005409.57−724143.5. We provide evidence that the supergiant star LHA 115-S 18 is the optical counterpart of the X-ray source, and we discuss different possibilities of the origin of its low X-ray luminosity ($L_X \sim 4 \times 10^{33}$ erg s⁻¹).

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Ages of young star clusters, massive blue stragglers and the upper mass limit of stars: analysing age-dependent stellar mass functions

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Massive stars rapidly change their masses through strong stellar winds and mass transfer in binary systems. The latter aspect is important for populations of massive stars as more than 70% of all O-stars are expected to interact with a binary companion during their lifetime. We show that such mass changes leave characteristic signatures in stellar mass
functions of young star clusters which can be used to infer their ages and to identify products of binary evolution. We model the observed present day mass functions of the young galactic Arches and Quintuplet star clusters using our rapid binary evolution code. We find that shaping of the mass function by stellar wind mass loss allows us to determine the cluster ages to $3.5 \pm 0.7$ Myr and $4.8 \pm 1.1$ Myr, respectively. Exploiting the effects of binary mass exchange on the cluster mass function, we find that the most massive stars in both clusters are rejuvenated products of binary mass transfer, i.e. the massive counterpart of classical blue straggler stars. This resolves the problem of an apparent age spread among the most luminous stars exceeding the expected duration of star formation in these clusters. We perform Monte Carlo simulations to probe stochastic sampling, which support the idea of the most massive stars being rejuvenated binary products. We find that the most massive star is expected to be a binary product after $1.0 \pm 0.7$ Myr in Arches and after $1.7 \pm 1.0$ Myr in Quintuplet. Today, the most massive $9 \pm 3$ stars in Arches and $8 \pm 3$ in Quintuplet are expected to be such objects. Our findings have strong implications for the stellar upper mass limit and solve the discrepancy between the claimed $150 \, M_\odot$ limit and observations of four stars with initial masses of $165–320 \, M_\odot$ in R 136 and of SN 2007bi, which is thought to be a pair-instability supernova from an initial $250 \, M_\odot$ star. Using the stellar population of R 136, we revise the upper mass limit to values in the range $200–500 \, M_\odot$.

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Spatially resolved LMC star formation history: I. Outside–in evolution of the outer LMC disk

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We study the evolution of three fields in the outer LMC disk $R_{gc} = 3.5–6.2$ kpc. Their star formation history indicates a stellar populations gradient such that younger stellar populations are more centrally concentrated. We identify two main star forming epochs, separated by a period of lower activity between $\sim 7$ and $\sim 4$ Gyr ago. Their relative importance varies from a similar amount of stars formed in the two epochs in the innermost field, to only $40\%$ of the stars formed in the more recent epoch in the outermost field. The young star forming epoch continues to the present time in the innermost field, but lasted only till $\sim 0.8$ and $1.3$ Gyr ago at $R_{gc} = 5^2$S and $7^2$1, respectively. This gradient is correlated with the measured H$\alpha$ column density and implies an outside–in quenching of the star formation, possibly related to a variation of the size of the H$\alpha$ disk. This could either result from gas depletion due to star formation or ram-pressure stripping, or from to the compression of the gas disk as ram-pressure from the Milky Way halo acted on the LMC interstellar medium. The latter two situations may have occurred when the LMC first approached the Milky Way.

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The VLT–FLAMES Tarantula Survey. XIII: On the nature of O Vz stars in 30 Doradus

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\textbf{Aims:} We test the hypothesis of O Vz stars (characterized by having He II 4686 stronger in absorption than other He lines in their blue–violet spectra) being at a younger evolutionary stage than are normal O-type dwarfs.

\textbf{Methods:} We have performed a quantitative spectroscopic analysis of a sample of 38 O Vz and 46 O V stars, identified by the VLT–FLAMES Tarantula Survey in the 30 Doradus region of the Large Magellanic Cloud (LMC). We obtained the stellar and wind parameters of both samples using the \textsc{fastwind} stellar atmosphere code and the \textsc{iacob-gbat} grid-based automatic tool. In the framework of a differential study, we compared the physical and evolutionary properties of both samples, regarding $T_{\text{eff}}$, $\log g$, $\log Q$ and $\log L$. We also investigated the predictions of the \textsc{fastwind} code about the O Vz phenomenon.

\textbf{Results:} We find a differential distribution of objects in terms of effective temperature, with O Vz stars dominant at intermediate values. The O Vz stars in 30 Doradus tend to be younger and less luminous, and they have weaker winds than the O V stars, but we also find examples with ages of 2–4 Myr and with luminosities and winds that are similar to those of normal O dwarfs. Moreover, the O Vz stars do not appear to have higher gravities than the O V stars. In addition to effective temperature and wind strength, our \textsc{fastwind} predictions indicate how important it is to take other stellar parameters (gravity and projected rotational velocity) into account for correctly interpreting the O Vz phenomenon.

\textbf{Conclusions:} In general, the O Vz stars appear to be on or very close to the ZAMS, but there are some examples where the Vz classification does not necessarily imply extreme youth. In particular, the presence of O Vz stars in our sample at more evolved phases than expected is likely a consequence of modest O-star winds owing to the low-metallicity environment of the LMC.

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A survey of infrared supernova remnants in the Large Magellanic Cloud

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We present a comprehensive infrared study of supernova remnants (SNRs) in the Large Magellanic Cloud (LMC) using near- to mid-infrared images taken by Infrared Array Camera (IRAC; 3.6, 4.5, 5.8, and 8 $\mu$m) and Multiband Imaging Photometer (MIPS; 24 and 70 $\mu$m) onboard the \textit{Spitzer} Space Telescope. Among the 47 bona fide LMC
SNRs, 29 were detected in infrared, giving a high detection rate of 62%. All 29 SNRs show emission at 24 µm, and 20 out of 29 show emission in one or several IRAC bands. We present their 4.5, 8, 24, and 70 µm images and a table summarizing their Spitzer fluxes. We find that the LMC SNRs are considerably fainter than the Galactic SNRs, and that, among the LMC SNRs, Type Ia SNRs are significantly fainter than core-collapse SNRs. We conclude that the MIPS emission of essentially all SNRs originates from dust emission, whereas their IRAC emissions originate from ionic/molecular lines, polycyclic aromatic hydrocarbons emission, or synchrotron emission. The infrared fluxes show correlation with radio and X-ray fluxes. For SNRs that have similar morphology in infrared and X-rays, the ratios of 24 to 70 µm fluxes have good correlation with the electron density of hot plasma. The overall correlation is explained well by the emission from collisionally-heated silicate grains of 0.1 µm size, but for mature SNRs with relatively low gas temperatures, the smaller-sized grain population is favored more. For those that appear different between infrared and X-rays, the emission in the MIPS bands is probably from dust heated by shock radiation.

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A multi-wavelength look at the young plerionic supernova remnant 0540−69.3

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We present a study of the plerionic supernova remnant 0540−69.3 in the LMC in X-ray, radio, optical, and infrared. We find that the shell of 0540−69.3 is characterized in the X-ray by thermal nonequilibrium plasma with depleted Mg and Si abundances and a temperature of $kT \sim 0.7$ keV. This thermal emission is superimposed with synchrotron emission in several regions. Based on X-ray spectra and on morphological considerations in all surveyed wavebands, we conclude that the shell is expanding into a clumpy and highly inhomogeneous medium. In one region of the shell we find an overabundance of Ne, suggesting the presence of ejecta near the edge of the remnant. We also see evidence for reheating of material via a reverse shock originating from the interaction of the supernova blast wave with a particularly dense cloud in the surrounding medium. Finally, we perform the first detailed study of the "halo" region extending 1.2–2.2 pc from the central pulsar. We detect the presence of thermal and nonthermal spectral components but do not find evidence for mixing or ejecta. We conclude that the thermal component is not a counterpart to similar optical and infrared halos and that it is most likely due to the projection of shell material along the line of sight.

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Not-so-simple stellar populations in the intermediate-age Large Magellanic Cloud star clusters NGC 1831 and NGC 1868

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Using a combination of high-resolution Hubble Space Telescope/WFPC2 observations, we explore the physical properties of the stellar populations in two intermediate-age star clusters in the Large Magellanic Cloud, NGC 1831 and NGC 1868, based on their color–magnitude diagrams. We show that both clusters exhibit extended main-sequence
turn-offs. To explain the observations, we consider variations in helium abundance, binarity, age dispersions, and fast rotation of the clusters' member stars. The observed narrow main sequence excludes significant variations in helium abundance in both clusters. We first establish the clusters' main-sequence binary fractions using the bulk of the clusters' main-sequence stellar populations > 1 mag below their turn-offs. The extent of the turn-off regions in color–magnitude space, corrected for the effects of binarity, implies that age spreads of order 300 Myr may be inferred for both clusters if the stellar distributions in color–magnitude space were entirely due to the presence of multiple populations characterized by an age range. Invoking rapid rotation of the population of cluster members characterized by a single age also allows us to match the observed data in detail. However, when taking into account the extent of the red clump in color–magnitude space, we encounter an apparent conflict for NGC 1831 between the age dispersion derived from that based on the extent of the main-sequence turn-off and that implied by the compact red clump. We therefore conclude that, for this cluster, variations in stellar rotation rate are preferred over an age dispersion. For NGC 1868, both models perform equally well.

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Four new X-ray-selected supernova remnants in the Large Magellanic Cloud

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Aims: We present a detailed multi-wavelength study of four new supernova remnants (SNRs) in the Large Magellanic Cloud (LMC). The objects were identified as SNR candidates in X-ray observations performed during the survey of the LMC with XMM–Newton.

Methods: Data obtained with XMM–Newton are used to investigate the morphological and spectral features of the remnants in X-rays. We measure the plasma conditions, look for supernova (SN) ejecta emission, and constrain some of the SNR properties (e.g., age and ambient density). We supplement the X-ray data with optical, infrared, and radio-continuum archival observations, which allow us to understand the conditions resulting in the current appearance of the remnants. Based on the spatially-resolved star formation history (SFH) of the LMC together with the X-ray spectra, we attempt to type the supernovae that created the remnants.

Results: We confirm all four objects as SNRs, to which we assign the names MCSNR J0508−6830, MCSNR J0511−6759, MCSNR J0514−6840, and MCSNR J0517−6759. In the first two remnants, an X-ray bright plasma is surrounded by very faint [S II] emission. The emission from the central plasma is dominated by Fe L-shell lines, and the derived iron abundance is greatly in excess of solar. This establishes their type Ia (i.e., thermonuclear) SN origin. They appear to be more evolved versions of other Magellanic Cloud iron-rich SNRs which are centrally-peaked in X-rays. From the two other remnants (MCSNR J0514−6840 and MCSNR J0517−6759), we do not see ejecta emission. At all wavelengths at which they are detected, the local environment plays a key role in their observational appearance. We present evidence that MCSNR J0517−6759 is close to and interacting with a molecular cloud, suggesting a massive progenitor.

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This paper reports variations of polycyclic aromatic hydrocarbons (PAHs) features that were found in Spitzer Space Telescope spectra of carbon-rich post-asymptotic giant branch (post-AGB) stars in the Large Magellanic Cloud (LMC). The paper consists of two parts. The first part describes our Spitzer spectral observing programme of 24 stars including post-AGB candidates. The latter half of this paper presents the analysis of PAH features in 20 carbon-rich post-AGB stars in the LMC, assembled from the Spitzer archive as well as from our own programme. We found that five post-AGB stars showed a broad feature with a peak at 7.7 μm, that had not been classified before. Further, the 10–13 μm PAH spectra were classified into four classes, one of which has three broad peaks at 11.3, 12.3 and 13.3 μm rather than two distinct sharp peaks at 11.3 and 12.7 μm, as commonly found in H II regions. Our studies suggest that PAHs are gradually processed while the central stars evolve from post-AGB phase to PNe, changing their composition before PAHs are incorporated into the interstellar medium. Although some metallicity dependence of PAH spectra exists, the evolutionary state of an object is more significant than its metallicity in determining the spectral characteristics of PAHs for LMC and Galactic post-AGB stars.

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Multi-frequency study of a new Fe-rich supernova remnant in the Large Magellanic Cloud, MCSNR J0508−6902


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We present a detailed radio, X-ray and optical study of a newly discovered Large Magellanic Cloud (LMC) supernova remnant (SNR) which we denote MCSNR J0508−6902. Observations from the Australian Telescope Compact Array (ATCA) and the XMM–Newton X-ray observatory are complemented by deep Hα images and Anglo-Australian Telescope AAΩ spectroscopic data to study the SNR shell and its shock-ionisation. Archival data at other wavelengths are also examined. The remnant follows a filled-in shell type morphology in the radio continuum and has a size of ∼ 74 pc × 57 pc at the LMC distance. The X-ray emission exhibits a faint soft shell morphology with Fe-rich gas in its interior – indicative of a Type Ia origin. The remnant appears to be mostly dissipated at higher radio-continuum frequencies leaving only the south-eastern limb fully detectable while in the optical it is the western side of the SNR shell that is clearly detected. The best-fit temperature to the shell X-ray emission (kT = 0.41+0.05−0.06 keV) is consistent with other large LMC SNRs. We determined an O/Fe ratio of < 21 and an Fe mass of 0.5–1.8 M⊙ in the interior of the remnant, both of which are consistent with the Type Ia scenario. We find an equipartition magnetic field for the remnant of ∼ 28 µG, a value typical of older SNRs and consistent with other analyses which also infer an older remnant.

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The VLT–FLAMES Tarantula Survey. XV. VFTS 822: a candidate Herbig B[e] star at low metallicity

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We report the discovery of the B[e] star VFTS 822 in the 30 Doradus star-forming region of the Large Magellanic Cloud, classified by optical spectroscopy from the VLT–FLAMES Tarantula Survey and complementary infrared photometry.
VFTS 822 is a relatively low-luminosity \((\log L = 4.04 \pm 0.25 \, L_\odot)\) B8[e] star. In this Letter, we evaluate the evolutionary status of VFTS 822 and discuss its candidacy as a Herbig B[e] star. If the object is indeed in the pre-main sequence phase, it would present an exciting opportunity to measure mass accretion rates at low metallicity spectroscopically, to understand the effect of metallicity on accretion rates.

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A multiwavelength analysis of planetary nebulae in the Large Magellanic Cloud

Warren A. Reid

This paper examines, compares and plots optical, near- and mid-infrared (MIR) photometric data for 605 planetary nebulae (PNe) in the Large Magellanic Cloud (LMC). With the aid of multi-wavelength surveys such as the Spitzer legacy programme Surveying the Agents of a Galaxy’s Evolution, the Two Micron All Sky Survey and the Magellanic Cloud Photometric Survey, plots have been constructed to expose the relative contributions from molecular hydrogen, polycyclic aromatic hydrocarbons, forbidden emission lines, warm dust continuum and stellar emission at various bands. Besides identifying trends, these plots have helped to reveal PN mimics including six previously known PNe in the outer LMC which are re-classified as other object types. Together with continuing follow-up optical observations, the data have enabled a substantial reduction in the number of PNe previously tagged as ‘likely’ and ‘possible’. The total number of LMC PNe is adjusted to 715 but with a greater degree of confidence in regard to classification. In each colour–colour plot, the more highly evolved LMC PNe are highlighted for comparison with younger, brighter PNe. The faintest and most evolved PNe typically cluster in areas of colour–colour space occupied by ordinary stars. Possible reasons for the wide disparity in infrared colour–colour ratios, such as evolution and dust composition, are presented for evaluation. A correlation is found between the optical luminosity of PNe, emission-line ratios and the MIR dust luminosity at various bands. Luminosity functions using the four Infrared Array Camera and Multiband Imaging Photometer of Spitzer (MIPS) \([24]\) bands are directly compared, revealing an increasing accumulation of PNe within the brightest two magnitudes at longer wavelengths. A correlation is also found between the MIPS \([24]\) band and the \([\text{O} \text{III} \, 5007 \text{~and} \, \text{H} \beta]\) fluxes.

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Search for binary central stars of the SMC PNe

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The Optical Gravitational Lensing Experiment (OGLE), originally designed to search for microlensing events, provides a rich and uniform data set suitable for studying the variability of certain types of objects. We used the OGLE data to study the photometry of central stars of planetary nebulae (PNe) in the Small Magellanic Cloud (SMC). In particular, we searched for close binary central stars with the aim to constrain the binary fraction and period distribution in the SMC. We also searched for PNe mimics and removed them from the PNe sample. We identified 52 counterparts of PNe in the SMC in the I-band images from the OGLE-II and OGLE-III surveys. We analysed the time-series photometry of the PNe. Spectra of the photometric variables were obtained to constrain the nature of the objects
or search for additional evidence for binarity. Eight variables were found. Of these, seven objects are PNe mimics, including one symbiotic star candidate. One close binary central star of PN with a period of 1.15 or 2.31 day was discovered. The obtained binary fraction for the SMC PNe and the observational biases are discussed in terms of the OGLE observations.

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The Wolf–Rayet stars in the Large Magellanic Cloud: A comprehensive analysis of the WN class

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Massive stars, although being important building blocks of galaxies, are still not fully understood. This holds especially for Wolf–Rayet stars with their strong mass loss, whose spectral analysis requires adequate model atmospheres. Following our comprehensive studies of the WR stars in the Milky Way, we now present spectroscopic analyses of almost all known WN stars in the Large Magellanic Cloud (LMC). For the quantitative analysis of the wind-dominated emission-line spectra we employ the Potsdam Wolf–Rayet (PoWR) model atmosphere code. By fitting synthetic spectra to the observed spectral energy distribution and the available spectra (ultraviolet and optical), we obtain the physical properties of 107 stars. We present the fundamental stellar and wind parameters for an almost complete sample of WN stars in the LMC. Among those stars which are putatively single, two different groups can be clearly distinguished. While 12% of our sample are more luminous than $10^6 L_\odot$ and contain a significant amount of hydrogen, 88% of the WN stars, with little or no hydrogen, populates the luminosity range between $log(L/L_\odot) = 5.3...5.8$. While the few extremely luminous stars ($log(L/L_\odot) > 6$), if indeed single stars, descended directly from the main sequence at very high initial masses, the bulk of WN stars have gone through the red-supergiant phase. According to their luminosities in the range of $log(L/L_\odot) = 5.3...5.8$, these stars originate from initial masses between 20 and 40 M_\odot. This mass range is similar to the one found in the Galaxy, i.e. the expected metallicity dependence of the evolution is not seen. Current stellar evolution tracks, even when accounting for rotationally induced mixing, still partly fail to reproduce the observed ranges of luminosities and initial masses. Moreover, stellar radii are generally larger, and effective temperatures correspondingly lower, than predicted from stellar evolution models, probably due to subphotospheric “inflation”.

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Variability of massive stars with known spectral types in the Small Magellanic Cloud using 8 years of OGLE-III data


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We present a variability study of 4646 massive stars in the Small Magellanic Cloud (SMC) with known spectral types
from the catalog of Bonanos et al. (2010) using the light curves from the OGLE-III database. The goal is to exploit
the time domain information available through OGLE-III to gain insight into the processes that govern the evolution
of massive stars. This variability survey of massive stars with known spectral types is larger than any previous survey
by a factor of 7. We find that 60% of our sample (2766 stars) show no significant variability and 40% (1880 stars)
exhibit variability distributed as follows: 807 stars display low-amplitude stochastic variability with fluctuations in
I-band of up to 0.05 mag, 443 stars present irregular variability of higher amplitude (76% of these are reported as
variables for the first time), 205 are eclipsing binaries (including 101 newly discovered systems), 50 are candidate
rotating variables, 126 are classical Cepheids, 188 stars exhibit short-term sinusoidal periodicity (P < 3 days) making
them candidate “slowly pulsating B stars” and non-radial Be pulsators, and 61 periodic stars exhibit longer periods.
We demonstrate the wealth of information provided in the time domain, by doubling the number of known massive
eclipsing binary systems and identifying 189 new candidate early-type Be and 20 Oe stars in the SMC. In addition,
we find that ∼80% of Be stars are photometrically variable in the OGLE-III time domain and provide evidence that
short-term pulsating stars with additional photometric variability are rotating close to their break-up velocity.

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Conference Paper

OB stars in the Leading Arm of the Magellanic Stream

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We present our spectroscopic program aimed to study some new interesting features recently discovered in the Mag-
ellan Cloud System. These were revealed by the spatial distribution of OB-type candidate stars, selected based on
UV, optical and IR photometry and proper motions from existing large-area catalogs. As a pilot study of our project,
we are studying OB-star candidates in the Leading Arm (LA) of the Magellanic Stream, a gaseous tidal structure with
no stellar counterpart known so far. Our targets group in three clumps near regions of high H I density in the LA. If
confirmed, these young stars would evidence recent star formation in the LA, and they would help better understand
and constrain the formation of the LA and its interactions with the Milky Way.

Oral contribution, published in “Fifty Years of Wide Field Studies in the Southern Hemisphere: Re-
solved Stellar Populations in the Galactic Bulge and the Magellanic Clouds”
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Post Doctoral research position

Applications are invited for one postdoctoral research position at the Space Telescope Science Institute (STScI) starting as early as summer 2014. The appointment is for one year initially, but up to three years. The successful applicant will work with Dr. Margaret Meixner on research of the life cycle of dust in the Magellanic Clouds. This life cycle includes identification of young stellar objects and the star formation process, identification of evolved stars and their dust production, studies of supernova dust production and the destruction of dust by supernova remnants, and studies of dust content in the interstellar medium.

These projects utilize space observatory survey data from the Spitzer SAGE and Herschel HERITAGE surveys of the Magellanic Clouds (SAGE-LMC, SAGE-SMC, SAGE-Spec and HERITAGE; for more information, see website sage.stsci.edu). Additional followup investigations using ALMA, HST, and ground based facilities is expected. Preparation for a guaranteed time program for JWST/MIRI observations is anticipated. Independent research in related areas will be supported and encouraged. Research experience in the areas of interstellar medium, star formation, evolved stars, supernova remnants, dust, radiative transfer or the Magellanic Clouds is desirable. A Ph.D. in astronomy or astrophysics is required.

STScI, located on Johns Hopkins University Campus in Baltimore, Maryland, offers an excellent benefit package, competitive salaries, and a stimulating work environment. STScI's pay is commensurate to the year of Ph.D.

See also https://rn11.ultipro.com/SPA1004/JobBoard/JobDetails.aspx?_ID=*638889591859873E