Figure 1: Fermi/LAT image of the SMC in γ-rays (arXiv:1008.2127), courtesy of Pierrick Martin. Contours are Hα, pulsars and supernova remnants are plotted as stars and bullets, respectively (see page 4 in this issue).
Dear Colleagues,

It is my pleasure to present you the 107th issue of the Magellanic Clouds Newsletter. The meeting at Bonn was very stimulating and exemplifies how much we are learning and how much we still do not know — thanks to Adam Ružička and Dominik Bomans for a perfect organisation. This issue of the Newsletter continues that trend, with a particularly high abundance of results on supernova remnants, new work on the Magellanic Stream, an important contribution to improving our knowledge of the proper motions of the Clouds, and a new look at the SMC — in γ-rays!

There is a great opportunity to work in Madison, Wisconsin, as a postdoctoral researcher — perhaps on the Magellanic Clouds? (See the advertisement at the back of the Newsletter.)

The next issue is planned to be distributed on the 1st of December 2010. Front cover pictures remain welcome!

Editorially Yours,
Jacco van Loon

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**Refereed Journal Papers**

*Spitzer view of young massive stars in the LMC HII complexes. II. N 159*

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The HII complex N 159 in the Large Magellanic Cloud (LMC) is used to study massive star formation in different environments, as it contains three giant molecular clouds (GMCs) that have similar sizes and masses but exhibit different intensities of star formation. We identify candidate massive young stellar objects (YSOs) using infrared photometry, and model their SEDs to constrain mass and evolutionary state. Good fits are obtained for less evolved Type I, I/II, and II sources. Our analysis suggests that there are massive embedded YSOs in N 159B, a maser source, and several ultracompact HII regions. Massive O-type YSOs are found in GMCs N 159-E and N 159-W, which are associated with ionized gas, i.e., where massive stars formed a few Myr ago. The third GMC, N 159-S, has neither O-type YSOs nor evidence of previous massive star formation. This correlation between current and antecedent formation of massive stars suggests that energy feedback is relevant. We present evidence that N 159-W is forming YSOs spontaneously, while collapse in N 159-E may be triggered. Finally, we compare star formation rates determined from YSO counts with those from integrated Hα and 24-μm luminosities and expected from gas surface densities. Detailed dissection of extragalactic GMCs like the one presented here is key to revealing the physics underlying commonly used star formation scaling laws.

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The 3-D structure of SN 1987A’s inner ejecta

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Observing the inner ejecta of a supernova is possible only in a handful of nearby supernova remnants. The core-collapse explosion mechanism has been extensively explored in recent models and predict large asymmetries. SN 1987A is the first modern stellar explosion that has been continuously observed from its beginning to the supernova remnant phase. Twenty years after the explosion, we are now able to observe the three-dimensional spatially resolved inner ejecta of this supernova. Detailed mapping of newly synthesised material and its radioactive decay daughter products sheds light on the explosion mechanism. This may reveal the geometry of the explosion and its connection to the equatorial ring and the outer rings around SN 1987A. We have used integral field spectroscopy to image the supernova ejecta and the equatorial ring in the emission lines of [Si i] + [Fe ii] (λ 1.64 µm) and He i (λ 2.058 µm). The spectral information can be mapped into a radial velocity image revealing the expansion of the ejecta both as projected onto the sky and perpendicular to the sky plane. The inner ejecta are spatially resolved in a North–South direction and are clearly asymmetric. Like the ring emission, the northern parts of the ejecta are blueshifted, while the material projected to the South of the supernova centre is moving away from us. We argue that the bulk of the ejecta is situated in the same plane as defined by the equatorial ring and does not form a bipolar structure as has been suggested. The exact shape of the ejecta is modelled and we find that an elongated triaxial ellipsoid fits the observations best. The velocity measured in the [Si i] + [Fe ii] line corresponds to ∼ 3000 km s−1 and is the same as the width of the IR [Fe ii] line profiles during the first years. From our spectral analyses of the ejecta spectrum we find that most of the He i, [Si i] and [Fe i–ii] emission originates in the core material which has undergone explosive nucleosynthesis. The He i emission may be the result of α-rich freeze-out if the positron energy is deposited locally. Our observations clearly indicate a non-symmetric explosion mechanism for SN 1987A. The elongation and velocity asymmetries point towards a large-scale spatial non-spherical distribution as predicted in recent explosion models. The orientation of the ejecta in the plane of the equatorial ring argues against a jet-induced explosion through the poles due to stellar rotation.

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Herschel observations of a newly discovered UX Ori star in the Large Magellanic Cloud

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The LMC star, SSTISAGE1C J050756.44−703453.9, was first noticed during a survey of EROS-2 lightcurves for stars with large irregular brightness variations typical of the R Corone Borealis (RCB) class. However, the visible spectrum showing emission lines including the Balmer and Paschen series as well as many Fe ii lines is emphatically not that of an RCB star. This star has all of the characteristics of a typical UX Ori star. It has a spectral type of approximately A2 and has excited an H ii region in its vicinity. However, if it is an LMC member, then it is very luminous for a Herbig Ae/Be star. It shows irregular drops in brightness of up to 2 mag, and displays the reddening and “blueing” typical of this class of stars. Its spectrum, showing a combination of emission and absorption lines, is typical of a UX Ori star that is in a decline caused by obscuration from the circumstellar dust. SSTISAGE1C J050756.44−703453.9 has a strong IR excess and significant emission is present out to 500 µm. Monte Carlo radiative transfer modeling of the SED requires that SSTISAGE1C J050756.44−703453.9 has both a dusty disk as well as a large extended diffuse envelope to fit both the mid- and far-IR dust emission. This star is a new member of the UX Ori subclass of the Herbig Ae/Be stars and only the second such star to be discovered in the LMC.

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Origin of the unusually low nitrogen abundances in young populations of the Large Magellanic Cloud

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It is a longstanding problem that H II regions and very young stellar populations in the Large Magellanic Cloud (LMC) have the nitrogen abundances ([N/H]) by a factor of \( \sim 7 \) lower than the solar value. We here discuss a new scenario in which the observed unusually low nitrogen abundances can be closely associated with recent collision and subsequent accretion of H i high velocity clouds (HVCs) that surround the Galaxy and have low nitrogen abundances. We show that if the observed low [N/H] is limited to very young stars with ages less than \( \sim 10^7 \) yr, then the collision/accretion rate of the HVCs onto the LMC needs to be \( \sim 0.2 \) M\( \odot \) yr\(^{-1} \) (corresponding to the total HVC mass of \( 10^6 \sim 10^7 \) M\( \odot \)) to dilute the original interstellar medium (ISM) before star formation. The required accretion rate means that even if the typical mass of HVCs accreted onto the LMC is \( \sim 10^7 \) M\( \odot \), the Galaxy needs to have \( \sim 2500 \) massive HVCs within the LMC’s orbital radius with respect to the Galactic center. The required rather large number of massive HVCs drives us to suggest that the HVCs are not likely to efficiently dilute the ISM of the LMC and consequently lower the [N/H]. We thus suggest the transfer of gas with low [N/H] from the Small Magellanic Cloud (SMC) to the LMC as a promising scenario that can explain the observed low [N/H].

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Simulations of the Magellanic Stream in a first infall scenario

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Recent high precision proper motions from the Hubble Space Telescope (HST) suggest that the Large and Small Magellanic Clouds (LMC and SMC, respectively) are either on their first passage or on an eccentric long period (\( > 6 \) Gyr) orbit about the Milky Way (MW). This differs markedly from the canonical picture in which the Clouds travel on a quasi-periodic orbit about the MW (period of \( \sim 2 \) Gyr). Without a short period orbit about the MW, the origin of the Magellanic Stream, a young (1–2 Gyr old) coherent stream of H i gas that trails the Clouds \( \sim 150^\circ \) across the sky, can no longer be attributed to stripping by MW tides and/or ram pressure stripping by MW halo gas. We propose an alternative formation mechanism in which material is removed by LMC tides acting on the SMC before the system is accreted by the MW. We demonstrate the feasibility and generality of this scenario using an N-body/SPH simulation with cosmologically motivated initial conditions constrained by the observations. Under these conditions we demonstrate that it is possible to explain the origin of the Magellanic Stream in a first infall scenario. This picture is generically applicable to any gas-rich dwarf galaxy pair infalling towards a massive host or interacting in isolation.

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Available from arXiv:1008.2210

Detection of the Small Magellanic Cloud in \( \gamma \)-rays with Fermi/LAT

The Fermi/LAT collaboration

1MPE, CESR and many others

The flux of \( \gamma \)-rays with energies \( > 100 \) MeV is dominated by diffuse emission from CRs illuminating the ISM of our
Galaxy through the processes of Bremsstrahlung, pion production and decay, and inverse-Compton scattering. The study of this diffuse emission provides insight into the origin and transport of CRs. We searched for $\gamma$-ray emission from the SMC in order to derive constraints on the CR population and transport in an external system with properties different from the Milky Way. We analysed the first 17 months of continuous all-sky observations by the Large Area Telescope of the Fermi mission to determine the spatial distribution, flux and spectrum of the $\gamma$-ray emission from the SMC. We also used past radio synchrotron observations of the SMC to study the population of CR electrons specifically. We obtained the first detection of the SMC in high-energy $\gamma$-rays, with an integrated $>100$ MeV flux of $(3.7 \pm 0.7) \times 10^{-8}$ ph cm$^{-2}$ s$^{-1}$, with additional systematic uncertainty of $<16\%$. The emission is steady and from an extended source $\sim 3^o$ in size. It is not clearly correlated with the distribution of massive stars or neutral gas, nor with known pulsars or SNRs, but a certain correlation with supergiant shells is observed. The observed flux implies an upper limit on the average CR nuclei density in the SMC of $\sim 15\%$ of the value measured locally in the Milky Way. The population of high-energy pulsars of the SMC may account for a substantial fraction of the $\gamma$-ray flux, which would make the inferred CR nuclei density even lower. The average density of CR electrons derived from radio synchrotron observations is consistent with the same reduction factor but the uncertainties are large. From our current knowledge of the SMC, such a low CR density does not seem to be due to a lower rate of CR injection and rather indicates a smaller CR confinement volume characteristic size.

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The orbital solution and spectral classification of the High-Mass X-Ray Binary IGR J01054$-$7253 in the Small Magellanic Cloud

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We present X-ray and optical data on the Be/X-ray binary (BeXRB) pulsar IGR J01054$-$7253 = SXP 11.5 in the Small Magellanic Cloud (SMC). Rossi X-ray Timing Explorer (RXTE) observations of this source in a large X-ray outburst reveal an 11.483 $\pm$ 0.002 s pulse period and show both the accretion driven spin-up of the neutron star and the motion of the neutron star around the companion through Doppler shifting of the spin period. Model fits to these data suggest an orbital period of 36.3 $\pm$ 0.4 d and $\dot{P}$ of $(4.7 \pm 0.3) \times 10^{-10}$ s$^{-1}$. We present an orbital solution for this system, making it one of the best described BeXRB systems in the SMC. The observed pulse period, spin-up and X-ray luminosity of SXP 11.5 in this outburst are found to agree with the predictions of neutron star accretion theory. Timing analysis of the long-term optical light curve reveals a periodicity of 36.70 $\pm$ 0.03 d, in agreement with the orbital period found from the model fit to the X-ray data. Using blue-end spectroscopic observations we determine the spectral type of the counterpart to be O9.5–B0 IV–V. This luminosity class is supported by the observed V-band magnitude. Using optical and near-infrared photometry and spectroscopy, we study the circumstellar environment of the counterpart in the months after the X-ray outburst.

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Submillimeter to centimeter excess emission from the Magellanic Clouds. II. On the nature of the excess

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Dust emission at submm to cm wavelengths is often simply the Rayleigh–Jeans tail of dust particles at thermal equilibrium and is used as a cold mass tracer in various environments including nearby galaxies. However, well-sampled spectral energy distributions of the nearby, star-forming Magellanic Clouds have a pronounced (sub-)millimeter excess (Israel et al. 2010). This study attempts to confirm the existence of such a millimeter excess above expected dust, free–free and synchrotron emission and to explore different possibilities for its origin. We model NIR to radio spectral energy distributions of the Magellanic Clouds with dust, free–free and synchrotron emission. A millimeter excess emission is confirmed above these components and its spectral shape and intensity are analysed in light of different scenarios: very cold dust, Cosmic Microwave Background (CMB) fluctuations, a change of the dust spectral index and spinning dust emission. We show that very cold dust or CMB fluctuations are very unlikely explanations for the observed excess in these two galaxies. The excess in the LMC can be satisfactorily explained either by a change of the spectral index due to intrinsic properties of amorphous grains, or by spinning dust emission. In the SMC however, due to the importance of the excess, the dust grain model including TLS/DCD effects cannot reproduce the observed emission in a simple way. A possible solution was achieved with spinning dust emission, but many assumptions on the physical state of the interstellar medium had to be made. Further studies, using higher resolution data from Planck and Herschel, are needed to probe the origin of this observed submm–cm excess more definitely. Our study shows that the different possible origins will be best distinguished where the excess is the highest, as is the case in the SMC.

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LABOCA observations of giant molecular clouds in the south west region of the Small Magellanic Cloud

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The amount of molecular gas is a key for understanding the future star formation in a galaxy. Because H\textsubscript{2} is difficult to observe directly in dense and cold clouds, tracers like CO are used. However, at low metallicities especially, CO only traces the shielded interiors of the clouds. mm dust emission can be used as a tracer to unveil the total dense gas masses. The comparison of masses deduced from the continuum SIMBA 1.2 mm emission and virial masses in a sample of giant molecular clouds (GMCs), in the SW region of the Small Magellanic Cloud (SMC), showed a discrepancy
that is in need of an explanation. This study aims at better assessing possible uncertainties on the dust emission observed in the sample of GMCs from the SMC and focuses on the densest parts of the GMCs where CO is detected. New observations were obtained with the LABOCA camera on the APEX telescope. All GMCs previously observed in CO are detected and their emission at 870 µm is compared to ancillary data. The different contributions to the sub-mm emission are estimated, as well as dust properties, in order to deduce molecular cloud masses precisely. The (sub-)mm emission observed in the GMCs in the SW region of the SMC is dominated by dust emission and masses are deduced for the part of each cloud where CO is detected and compared to the virial masses. The mass discrepancy between both methods is confirmed at 870 µm with the LABOCA observations: the virial masses are on average 4 times smaller than the masses of dense gas deduced from dust emission, contrary to what is observed for equivalent clouds in our Galaxy. The origin of this mass discrepancy in the SMC remains unknown. The direct interpretation of this effect is that the CO linewidth used to compute virial masses do not measure the full velocity distribution of the gas. Geometrical effects and uncertainties on the dust properties are also discussed.

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Is there a metallicity gradient in the Large Magellanic Cloud?
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A small but significant radial gradient in the mean periods of Large Magellanic Cloud (LMC) RR Lyrae variables is established from the OGLE-III survey data. This is interpreted as a metallicity gradient but other possibilities are also discussed. Data on the ratio of photometrically selected C- and M-type asymptotic giant branch (AGB) stars in the LMC, kindly provided by M-R.L. Cioni, are reanalysed. Removing the effects of bias leads to conclusions strikingly different to the original ones. There is a slight gradient of the C/M ratio in the inner part of the LMC, which might be due to a very small mean metallicity gradient. In the outer part of the LMC the C/M ratio drops dramatically. The most likely reason for this is that the proportion of older stars increases in the outer regions. The mean metallicity of the inner AGB star population estimated from the C/M ratio is lower than for intermediate age LMC clusters and suggest that this population is in the mean older than the clusters and has a mean age which falls in the LMC cluster age gap.

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The 200-degree long Magellanic Stream system
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We establish that the Magellanic Stream (MS) is some 40° longer than previously known with certainty and that the entire MS and Leading Arm (LA) system is thus at least 200° long. With the Green Bank Telescope, we conducted a ∼ 200 square degree, 21-cm survey at the tip of the MS to substantiate the continuity of the MS between the Hulsbosch & Wakker data and the MS-like emission reported by Braun & Thilker. Our survey, in combination with the Arecibo survey by Stanimirović et al., shows that the MS gas is continuous in this region and that the MS is at least ∼ 140° long. The MS-tip is composed of a multitude of forks and filaments. We identify a new filament on the eastern side of the MS that significantly deviates from the equator of the MS coordinate system for more than ∼ 45°. Additionally, we find a previously unknown velocity inflection in the MS-tip near MS longitude $L_{MS} = -120°$.
at which the velocity reaches a minimum and then starts to increase. We find that five compact high velocity clouds cataloged by de Heij et al, as well as Wright’s Cloud are plausibly associated with the MS because they match the MS in position and velocity. The mass of the newly-confirmed \(\sim 40 \times 10^7 M_\odot\) (including Wright’s Cloud increases this by \(\sim 50\%\)) and increases the total mass of the MS by \(\sim 4\%\). However, projected model distances of the MS at the tip are generally quite large and, if true, indicate that the mass of the extension might be as large as \(\sim 10^8 M_\odot\). From our combined map of the entire MS, we find that the total column density (integrated transverse to the MS) drops markedly along the MS and follows an exponential decline with MS of \(N(\text{HI}) = 5.9 \times 10^{21} \exp(L_{\text{MS}}/19.3\degree)\) cm\(^{-2}\). Under the assumption that the observed sinusoidal velocity pattern of the LMC filament of the MS is due to the origin of the MS from a rotating LMC, we estimate that the age of the \(\sim 140\degree\)-long MS is \(\sim 2.5\) Gyr. This coincides with bursts of star formation in the Magellanic Clouds and a possible close encounter of these two galaxies with each other that could have triggered the formation of the MS. These newly observed characteristics of the MS offer additional constraints for MS simulations. In the Appendix we describe a previously little discussed problem with a standing wave pattern in GBT H\(_i\) data and detail a method for removing it.

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Available from arXiv:1009.0001
gas contains fainter clumps but with higher velocities than the blueshifted gas. The major axis of the explosion is inclined at $\sim 40^\circ$ to the line of sight. This structure shows that the supernova explosion has been influenced both by the rotation of the progenitor star and, presumably, by a global rotational instability following core collapse.


*Available from http://hdl.handle.net/102.100.100/4449*

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**The 3D structure of N 132D in the LMC: A late-stage young supernova remnant**

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We have used the Wide Field Spectrograph (WiFeS) on the 2.3m telescope at Siding Spring Observatory to map the $\text{[O} \text{iii}]$ 5007 Å dynamics of the young oxygen-rich supernova remnant N 132D in the Large Magellanic Cloud. From the resultant data cube, we have been able to reconstruct the full 3D structure of the system of $\text{[O} \text{iii}]$ filaments. The majority of the ejecta form a ring of $\sim 12$ pc in diameter inclined at an angle of $\sim 25^\circ$ to the line of sight. We conclude that SNR N 132D is approaching the end of the reverse shock phase before entering the fully thermalized Sedov phase of evolution. We speculate that the ring of oxygen-rich material comes from ejecta in the equatorial plane of a bipolar explosion, and that the overall shape of the SNR is strongly influenced by the pre-supernova mass loss from the progenitor star. We find tantalizing evidence of a polar jet associated with a very fast oxygen-rich knot, and clear evidence that the central star has interacted with one or more dense clouds in the surrounding ISM.

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**Multi-frequency study of Local Group supernova remnants — The curious case of the Large Magellanic Cloud SNR J0528−6714**

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**Context.** The SNRs known in the Local Group show a variety of morphological structures that are relatively uncorrelated in the different wavelength bands. This variety is probably caused by the different conditions in the surrounding medium with which the remnant interacts.

**Aims.** Recent ATCA, XMM-Newton and MCELS observations of the Magellanic Clouds (MCs) cover a number of new and known SNRs which are poorly studied, such as SNR J0528−6714. This particular SNR exhibits luminous radio-continuum emission, but is one of the unusual and rare cases without detectable optical and very faint X-ray emission (initially detected by ROSAT and listed as object [HP99] 498). We used new multi-frequency radio-continuum surveys and new optical observations at H$\alpha$, [S$\text{ii}$] and [O$\text{iii}$] wavelengths, in combination with XMM-Newton X-ray data, to investigate the SNR properties and to search for a physical explanation for the unusual appearance of this SNR.

**Methods.** We analysed the X-ray and radio-continuum spectra and present multi-wavelength morphological studies of this SNR.

**Results.** We present the results of new moderate resolution ATCA observations of SNR J0528−6714. We found that this object is a typical older SNR with a radio spectral index of $\alpha = -0.36 \pm 0.09$ and a diameter of $D = 52.4 \pm 1.0$ pc. Regions of moderate and somewhat irregular polarisation were detected which are also indicative of an older SNR.
Using a non-equilibrium ionisation collisional plasma model to describe the X-ray spectrum, we find temperatures $kT$ of 0.26 keV for the remnant. The low temperature, low surface brightness, and large extent of the remnant all indicate a relatively advanced age. The near circular morphology indicates a type Ia event.

Conclusions. Our study revealed one of the most unusual cases of SNRs in the Local Group of galaxies – a luminous radio SNR without optical counterpart and, at the same time, very faint X-ray emission. While it is not unusual to not detect an SNR in the optical, the combination of faint X-ray and no optical detection makes this SNR very unique.

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The mass-loss return from evolved stars to the Large Magellanic Cloud
III. Dust properties for carbon-rich asymptotic giant branch stars


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We present a radiative transfer model for the circumstellar dust shell around a Large Magellanic Cloud (LMC) long-period variable (LPV) previously studied as part of the Optical Gravitational Lensing Experiment (OGLE) survey of the LMC. OGLE LMC LPV 28579 (SAGE J051306.40−690946.3) is a carbon-rich asymptotic giant branch (AGB) star for which we have Spitzer broadband photometry and spectra from the SAGE and SAGE-Spec programs along with broadband UBVIJHKs photometry. By modeling this source, we obtain a baseline set of dust properties to be used in the construction of a grid of models for carbon stars. We reproduce the spectral energy distribution of the source using a mixture of amorphous carbon and silicon carbide with 15% SiC by mass. The grain sizes are distributed according to the KMH model, with $\gamma = 3.5$, $a_{\text{min}} = 0.01 \mu m$ and $a_0 = 1.0 \mu m$. The best-fit model produces an optical depth of 0.28 for the dust shell at the peak of the SiC feature (11.3 $\mu m$), with an inner radius of about 1430 $R_\odot$ or 4.4 times the stellar radius. The temperature at this inner radius is 1310 K. Assuming an expansion velocity of 10 km s$^{-1}$, we obtain a dust mass-loss rate of $2.5 \times 10^{-9} M_\odot$ yr$^{-1}$. We calculate a 15% variation in this mass-loss rate by testing the sensitivity of the fit to variation in the input parameters. We also present a simple model for the molecular gas in the extended atmosphere that could give rise to the 13.7 $\mu m$ feature seen in the spectrum. We find that a combination of CO and C$_2$H$_2$ gas at an excitation temperature of about 1000 K and column densities of $3 \times 10^{21}$ cm$^{-2}$ and $10^{19}$ cm$^{-2}$ respectively are able to reproduce the observations. Given that the excitation temperature is close to the temperature of the dust at the inner radius, most of the molecular contribution probably arises from this region. The luminosity corresponding to the first epoch of SAGE observations is 6580 L$_\odot$. For an effective temperature of about 3000 K, this implies a stellar mass of 1.5–2 $M_\odot$ and an age of 1–2.5 Gyr for OGLE LMC LPV 28579. We calculate a gas mass-loss rate of $5.0 \times 10^{-7} M_\odot$ yr$^{-1}$ assuming a gas:dust ratio of 200. This number is comparable to the gas mass-loss rates estimated from the period, color and 8 $\mu m$ flux of the source.

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Formation of fullerenes in H-containing Planetary Nebulae

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Hydrogen depleted environments are considered an essential requirement for the formation of fullerenes. The recent detection of C60 and C70 fullerenes in what was incorrectly interpreted as the hydrogen-poor inner region of a post-final helium shell flash Planetary Nebula (PN) seemed to confirm this picture. Here, we present strong evidence that challenges the current paradigm regarding fullerene formation, showing that it can take place in circumstellar environments containing hydrogen. We report the simultaneous detection of Polycyclic Aromatic Hydrocarbons (PAHs) and fullerenes towards C-rich and H-containing PNe belonging to environments with very different chemical histories such as our own Galaxy and the Small Magellanic Cloud. We suggest that PAHs and fullerenes may be formed by the photochemical processing of hydrogenated amorphous carbon. These observations have profound implications on our current understanding of the chemistry of large organic molecules as well as the chemical processing in space.

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Proper motion study of the Magellanic Clouds using SPM material

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Absolute proper motions are determined for stars and galaxies to \( V = 17.5 \) over a 450 square-degree area that encloses both Magellanic Clouds. The proper motions are based on photographic and CCD observations of the Yale/San Juan Southern Proper Motion program, which span over a baseline of 40 years. Multiple, local relative proper motion measures are combined in an overlap solution using photometrically selected Galactic Disk stars to define a global relative system that is then transformed to absolute using external galaxies and Hipparcos stars to tie into the ICRS. The resulting catalog of 1.4 million objects is used to derive the mean absolute proper motions of the Large Magellanic Cloud and the Small Magellanic Cloud; \((\mu_\alpha \cos \delta, \mu_\delta)_{\text{LMC}} = (1.89, +0.39) \pm (0.27, 0.27) \) mas yr\(^{-1}\) and \((\mu_\alpha \cos \delta, \mu_\delta)_{\text{SMC}} = (0.98, -1.01) \pm (0.30, 0.29) \) mas yr\(^{-1}\). These mean motions are based on best-measured samples of 3822 LMC stars and 964 SMC stars. A dominant portion (0.25 mas yr\(^{-1}\)) of the formal errors is due to the estimated uncertainty in the inertial system of the Hipparcos Catalog stars used to anchor the bright end of our proper motion measures. A more precise determination can be made for the proper motion of the SMC relative to the LMC; \((\mu_\alpha \cos \delta, \mu_\delta)_{\text{SMC-LMC}} = (-0.91, -1.49) \pm (0.16, 0.15) \) mas yr\(^{-1}\). This differential value is combined with measurements of the proper motion of the LMC taken from the literature to produce new absolute proper-motion determinations for the SMC, as well as an estimate of the total velocity difference of the two clouds to within \( \pm 54 \) km s\(^{-1}\). The absolute
proper motion results are consistent with the Clouds’ orbits being marginally bound to the Milky Way, albeit on an elongated orbit. The inferred relative velocity between the Clouds places them near their binding energy limit and, thus, no definitive conclusion can be made as to whether or not the Clouds are bound to one another.

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Non-linear modelling of beat Cepheids: resonant and non-resonant models

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Context. Double-periodic (beat) Cepheids are important astrophysical objects which allow testing both the stellar evolution and stellar pulsation theories, as well as the physical properties of matter in stellar conditions. However, the phenomenon of double-periodic pulsation is still poorly understood. Recently we rediscussed the problem of modelling the double-periodic pulsation with non-linear hydrocodes. We showed that the published non-resonant double-mode models are incorrect, because they exclude the negative buoyancy effects.

Aims. We continue our efforts to verify whether the Kuhfuß one-equation convection model with negative buoyancy included can reproduce the double-periodic Cepheid pulsation.

Methods. Using the direct time integration hydrocode, which implements the Kuhfuß convection model, we search for stable double-periodic Cepheid models. We search for models pulsating in both fundamental and first overtone modes (F+1O), as well as in the two lowest order overtones (1O+2O). In the latter case, we focus on reproducing double-overtone Cepheids of the Large Magellanic Cloud (LMC).

Results. We have found full amplitude non-linear beat Cepheid models of both types, F+1O and 1O+2O. In the case of F+1O models, the beat pulsation is most likely caused by the three-mode resonance, \(2\omega_1 = \omega_0 + \omega_2\), while in the double-overtone models the underlying mechanism (resonant or non-resonant) cannot be identified beyond doubt. Double-periodic models found in our survey exist, however, only in narrow period ranges and cannot explain the majority of the observed double-periodic objects.

Conclusions. With only little doubt left, we conclude that current one dimensional one-equation convection models are incapable of reproducing the majority of the observed beat Cepheids. Among the shortcomings of current pulsation hydrocodes, the simple treatment of convection seems to be the most severe one. Growing evidence for the presence of non-radial modes in Cepheids suggests that the interaction between radial and non-radial modes should also be investigated.

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The Optical Gravitational Lensing Experiment. The OGLE-III Catalog of Variable Stars. IX. RR Lyr stars in the Small Magellanic Cloud

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The ninth part of the OGLE-III Catalog of Variable Stars (OIII-CVS) comprises RR Lyr stars in the Small Magellanic
Cloud (SMC). Our sample consists of 2475 variable stars, of which 1933 pulsate in the fundamental mode (RRab), 175 are the first overtone pulsators (RRc), 258 oscillate simultaneously in both modes (RRd) and 109 stars are suspected second-overtone pulsators (RRe). 30 objects are Galactic RR Lyr stars seen in the foreground of the SMC. We discuss some statistical features of the sample. Period distributions show distinct differences between SMC and LMC populations of RR Lyr variable stars, with the SMC stars having on average longer periods. The mean periods for RRab, RRc and RRe stars are 0.596, 0.366 and 0.293 days, respectively. The mean apparent magnitudes of RRab stars are equal to 19.70 mag in the \( V \)-band and 19.12 mag in the \( I \)-band. Spatial distribution of RR Lyr stars shows that the halo of the SMC is roughly round in the sky, however the density map reveals two maxima near the center of the SMC.

For each object the multi-epoch \( V \)- and \( I \)-band photometry collected over 8 or 13 years of observations and finding charts are available to the astronomical community from the OGLE Internet archive.

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The Optical Gravitational Lensing Experiment. The OGLE-III Catalog of Variable Stars. X. Enigmatic class of double-periodic variables in the Large Magellanic Cloud

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The tenth part of the OGLE-III Catalog of Variable Stars contains 125 Double Periodic Variables (DPVs) from the Large Magellanic Cloud. DPVs are semi-detached binaries which show additional variability with a period around 33 times longer than the orbital period. The cause of this long cycle is not known and previous studies suggest it involves circumbinary matter.

We discuss the properties of the whole sample of the LMC DPVs and put more attention to particularly interesting objects which may be crucial for verifying hypothesis explaining long cycle variability. Secondary eclipses of one of the objects disappear during some orbital cycles and primary eclipses are deeper during long cycle minimum.

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The SAGE-Spec Spitzer Legacy program: The life-cycle of dust and gas in the Large Magellanic Cloud. Point source classification I

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We present the classification of 197 point sources observed with the Infrared Spectrograph in the SAGE-Spec Legacy program on the Spitzer Space Telescope. We introduce a decision-tree method of object classification based on infrared spectral features, continuum and spectral energy distribution shape, bolometric luminosity, cluster membership, and variability information, which is used to classify the SAGE-Spec sample of point sources. The decision tree has a broad application to mid-infrared spectroscopic surveys, where supporting photometry and variability information are available. We use these classifications to make deductions about the stellar populations of the Large Magellanic Cloud and the success of photometric classification methods. We find 90 asymptotic giant branch (AGB) stars, 29 young stellar objects, 23 post-AGB objects, 19 red supergiants, eight stellar photospheres, seven background galaxies, seven planetary nebulae, two HII regions and 12 other objects, seven of which remain unclassified.

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Can an underestimation of opacity explain B-type pulsators in the SMC?

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Slowly Pulsating B and β Cephei are κ mechanism driven pulsating B stars. That κ mechanism works since a peak in the opacity due to a high number of atomic transitions from iron-group elements occurs in the area of log T ≈ 5.3. Theoretical results predict very few SPBs and no β Cep to be encountered in low metallicity environments such as the Small Magellanic Cloud. However recent variability surveys of B stars in the SMC reported the detection of a significant number of SPB and β Cep candidates. Though the iron content plays a major role in the excitation of
β Cep and SPB pulsations, the chemical mixture representative of the SMC B stars such as recently derived does not leave room for a significant increase of the iron abundance in these stars. Whilst abundance of iron-group elements seems reliable, is the opacity in the iron-group elements bump underestimated? We determine how the opacity profile in B-type stars should change to excite SPB and β Cep pulsations in early-type stars of the SMC.

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The Large Magellanic Cloud: A power spectral analysis of Spitzer images

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We present a power spectral analysis of Spitzer images of the Large Magellanic Cloud. The power spectra of the FIR emission show two different power laws. At larger scales (kpc) the slope is \( \sim -1.6 \), while at smaller ones (tens to few hundreds of parsecs) the slope is steeper, with a value \( \sim -2.9 \). The break occurs at a scale around 100–200 pc. We interpret this break as the scale height of the dust disk of the LMC. We perform high resolution simulations with and without stellar feedback. Our AMR hydrodynamic simulations of model galaxies using the LMC mass and rotation curve, confirm that they have similar two-component power-laws for projected density and that the break does indeed occur at the disk thickness. Power spectral analysis of velocities betrays a single power law for in-plane components. The vertical component of the velocity shows a flat behavior for large structures and a power law similar to the in-plane velocities at small scales. The motions are highly anisotropic at large scales, with in-plane velocities being much more important than vertical ones. In contrast, at small scales, the motions become more isotropic.

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Orbit of the Large Magellanic Cloud in a dynamical model for the Local Group

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A mass model that includes galaxies in and near the Local Group and an external mass in the direction of the Maffei system, with the condition from cosmology that protogalaxies have small peculiar velocities at high redshifts, allows a plausible picture for the past motion of the Large Magellanic Cloud relative to the Milky Way. The model also fits the proper motions of M 33 and IC 10.

Oral contribution, published in arXiv
Available from arXiv:1009.0496
GASKAP — A Galactic spectral line survey with the Australian Square Kilometre Array Pathfinder

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One of the Survey Science Projects that the Australian Square Kilometre Array Pathfinder (ASKAP) telescope will do in its first few years of operation is a study of the 21-cm line of \(\text{H}_1\) and the 18-cm lines of OH in the Galactic Plane and the Magellanic Clouds and Stream. The wide-field ASKAP can survey a large area with very high sensitivity much faster than a conventional telescope because of its focal plane array of receiver elements. The brightness sensitivity for the widespread spectral line emission of the interstellar medium depends on the beam size and the survey speed. In the GASKAP survey, maps with different resolutions will be synthesized simultaneously; these will be matched to different scientific applications such as diffuse \(\text{H}_1\) and OH emission, OH masers, and \(\text{H}_1\) absorption toward background continuum sources. A great many scientific questions will be answered by the GASKAP survey results; a central topic is the exchange of matter and energy between the Milky Way disk and halo. The survey will show how neutral gas at high altitude (\(z\)) above the disk, like the Magellanic Stream, makes its way down through the halo, what changes it experiences along the way, and how much is left behind.

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ASKAP and MeerKAT surveys of the Magellanic Clouds

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The Magellanic Clouds are a stepping stone from the overwhelming detail of the Milky Way in which we are immersed, to the global characteristics of galaxies both in the nearby and distant universe. They are interacting, gas-rich dwarf galaxies of sub-solar metallicity, not unlike the building blocks that assembled the large galaxies that dominate groups and clusters, and representative of the conditions at the height of cosmic star formation. The Square Kilometre Array (SKA) can make huge strides in understanding galactic metabolism and the ecological processes that govern star formation, by observations of the Magellanic Clouds and other, nearby Magellanic-type irregular galaxies. Two programmes with SKA Pathfinders attempt to pave the way: the approved Galactic ASKAP Spectral Line Survey (GASKAP) includes a deep survey in \(\text{H}_1\) and OH of the Magellanic Clouds, whilst MagiKAT is proposed to perform more detailed studies of selected regions within the Magellanic Clouds — also including Faraday rotation measurements and observations at higher frequencies. These surveys also close the gap with the revolutionizing surveys at far-IR wavelengths with the Spitzer Space Telescope and Herschel Space Observatory.

Poster contribution, published in "A New Golden Age in Astronomy", ISKAF 2010 Science Meeting, Proceedings of Science
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Detailed chemical abundances of globular clusters in Local Group dwarf galaxies

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We present detailed chemical abundances of Fe, Ca and Ba for 17 globular clusters (GCs) in 5 Local Group dwarf galaxies: NGC 205, NGC 6822, WLM, the SMC and LMC. These abundances are part of a larger sample of over 20 individual elements measured in GCs in these galaxies using a new analysis method for high resolution, integrated light spectra. Our analysis also provides age and stellar population constraints. The existence of GCs in dwarf galaxies with a range of ages implies that there were episodes of rapid star formation throughout the history of these galaxies; the abundance ratios of these clusters suggest that the duration of these bursts varied considerably from galaxy to galaxy. We find evolution of Fe, Ca, and Ba with age in the LMC, SMC, and NGC 6822 that is consistent with extended, lower-efficiency SF between bursts, with an increasing contribution of low-metallicity AGB ejecta at late times. Our sample of GCs in NGC 205 and WLM are predominantly old and metal-poor with high $\text{[Ca/Fe]}$ ratios, implying that the early history of these galaxies was marked by consistently high SF rates.

Poster contribution, published in ”A Universe of Dwarf Galaxies”, Lyon, June 14–18, 2010
Available from arXiv:1009.4195

Job Advert

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The Department of Astronomy at the University of Wisconsin – Madison announces the newly-initiated Grainger Postdoctoral Fellowship. The Fellowship provides opportunities for outstanding independent postdoctoral research on problems that are broadly related to the scientific interests of the department. The current departmental areas of expertise include observational, experimental and theoretical research in: stellar astrophysics and star formation, the interstellar and intergalactic media, extragalactic astrophysics, cosmology, plasma astrophysics, high energy astrophysics, and astronomical instrumentation.

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Material can be sent electronically to graingerpostdoc@astro.wisc.edu.

Applications received by December 1, 2010 are guaranteed full consideration.
Email inquiries can be directed to Prof. Snežana Stanimirović, sstanimi@astro.wisc.edu.

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