Editorial

Dear Colleagues,

It is my pleasure to present you the 95th issue of the Magellanic Clouds Newsletter.

The OGLE III team have started to disseminate their results, and there are other recent results on variable stars, including a very interesting work on the mass loss of Cepheids (Neilson & Lester). Check out the abstracts of the first sixteen IAU 256 proceedings papers too.

Now that the Magellanic Clouds are again high in the (Southern) night sky, we can imagine the exciting new discoveries that are being made.

The next issue will be distributed on the 1st of December 2008; the deadline for contributions is the 30th of November.

Editorially Yours,

Jacco van Loon
The Optical Gravitational Lensing Experiment. Final Reductions of the
OGLE-III Data

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We describe methods applied to the final photometric reductions and calibrations to the standard system of the images
collected during the third phase of the Optical Gravitational Lensing Experiment survey — OGLE-III. Astrometric
reduction methods are also presented.
The OGLE-III data constitute a unique data set covering the Magellanic Clouds, Galactic bulge and Galactic disk
fields monitored regularly every clear night since 2001 and being significant extension and continuation of the earlier
OGLE observations. With the earlier OGLE-II and OGLE-I photometry some of the observed fields have now 16-year
long photometric coverage.

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The Optical Gravitational Lensing Experiment. OGLE-III Photometric
Maps of the Large Magellanic Cloud

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We present the OGLE-III Photometric Maps of the Large Magellanic Cloud. They cover about 40 square degrees of
the LMC and contain mean, calibrated \( V \)\( I \) photometry and astrometry of about 35 million stars observed during seven
observing seasons of the third phase of the Optical Gravitational Lensing Experiment — OGLE-III.
We discuss the quality of data and present color–magnitude diagrams of selected fields. The OGLE-III Photometric
Maps of the LMC are available to the astronomical community from the OGLE Internet archive.

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The Optical Gravitational Lensing Experiment. Triple-Mode and
1O/3O Double-Mode Cepheids in the Large Magellanic Cloud

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We report the discovery of three new triple-mode classical Cepheids in the Large Magellanic Cloud, two of which
with the fundamental, first overtone and second overtone excited, and one pulsating simultaneously in the first three
overtones. Thus, the number of triple-mode Cepheids in the LMC is increased to five. We also present two objects
belonging probably to a new type of double-mode Cepheids having the first and third overtones excited. We measure
the rates of period change in these stars and detect decreasing of the periods in two of them, what is in conflict with theoretical predictions.

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The Optical Gravitational Lensing Experiment. The OGLE-III Catalog of Variable Stars. I. Classical Cepheids in the Large Magellanic Cloud

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We present the first part of a new catalog of variable stars (OIII-CVS) compiled from the data collected in the course of the third phase of the Optical Gravitational Lensing Experiment (OGLE-III). In this paper we describe the catalog of 3361 classical Cepheids detected in the \(\sim 40\) square degrees area in the Large Magellanic Cloud. The sample consists of 1848 fundamental-mode (F), 1228 first-overtone (1O), 14 second-overtone (2O), 61 double-mode F/1O, 203 double-mode 1O/2O, 2 double-mode 1O/3O, and 5 triple-mode classical Cepheids. This sample is supplemented by the list of 23 ultra-low amplitude variable stars which may be Cepheids entering or exiting instability strip.

The catalog data include \(V\) I high-quality photometry collected since 2001, and for some of the stars supplemented by OGLE-II photometry obtained between 1997 and 2000. We provide basic parameters of the stars: coordinates, periods, mean magnitudes, amplitudes and parameters of the Fourier light curves decompositions. Our sample of Cepheids is cross-identified with previously published catalogs of these variables in the LMC. Individual objects of particular interest are discussed, including single-mode second-overtone Cepheids, multiperiodic pulsators with unusual period ratios or Cepheids in eclipsing binary systems.

We discuss the variations of the Fourier coefficients with periods and point out on the sharp feature for periods around 0.35 days of first-overtone Cepheids, which can be explained by the occurrence of 2:1 resonance between the first and fifth overtone. Similar behavior at \(P \approx 3\) days for 1O Cepheids and \(P \approx 10\) days for F Cepheids are also interpreted as an effect of resonances between two radial modes. We fit the period–luminosity relations to our sample of Cepheids and compare these functions with the previous determinations.

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AKARI IRC survey of the Large Magellanic Cloud: Outline of the survey and initial results

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We observed an area of 10 deg\(^2\) of the Large Magellanic Cloud using the Infrared Camera on board AKARI. The
observations were carried out using five imaging filters (3, 7, 11, 15, and 24 $\mu$m) and a dispersion prism (2–5 $\mu$m, $\lambda/\Delta \lambda \sim 20$) equipped in the IRC. This paper describes the outline of our survey project and presents some initial results using the imaging data that detected over $5.9 \times 10^5$ near-infrared and $6.4 \times 10^4$ mid-infrared point sources. The 10 $\sigma$ detection limits of our survey are about 16.5, 14.0, 12.3, 10.8, and 9.2 in Vega-magnitude at 3, 7, 11, 15, and 24 $\mu$m, respectively. The 11 and 15 $\mu$m data, which are unique to AKARI IRC, allow us to construct color-magnitude diagrams that are useful to identify stars with circumstellar dust. We found a new sequence in the color–magnitude diagram, which is attributed to red giants with luminosity fainter than that of the tip of the first red giant branch. We suggest that this sequence is likely to be related to the broad emission feature of aluminium oxide at 11.5 $\mu$m. The 11 and 15 $\mu$m data also indicate that the (11) – (15) micron color of both oxygen-rich and carbon-rich red giants once becomes blue and then turns red again in the course of their evolution, probably due to the change in the flux ratio of the silicate or silicon carbide emission feature at 10 or 11.3 $\mu$m to the 15 $\mu$m flux.

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The Properties of Long-Period Variables in the Large Magellanic Cloud from MACHO
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We present a new analysis of the long-period variables in the Large Magellanic Cloud (LMC) from the MACHO Variable Star Catalog. Three-quarters of our sample of evolved, variable stars have periodic light curves. We characterize the stars in our sample using the multiple periods found in their frequency spectra. Additionally, we use single-epoch Two Micron All Sky Survey measurements to construct the average infrared light curves for different groups of these stars. Comparison with evolutionary models shows that stars on the red giant branch (RGB) or the early asymptotic giant branch (AGB) often show non-periodic variability, but begin to pulsate with periods on the two shortest period-luminosity sequences (3 & 4) when they brighten to $K_s \sim 13$. The stars on the thermally pulsing AGB are more likely to pulsate with longer periods that lie on the next two P–L sequences (1 & 2), including the sequence associated with the Miras in the LMC. The Petersen diagram and its variants show that multi-periodic stars on each pair of these sequences (3 & 4, and 1 & 2) typically pulsate with periods associated only with that pair. The periods in these multi-periodic stars become longer and stronger as the star evolves. We further constrain the mechanism behind the long secondary periods (LSPs) seen in half of our sample, and find that there is a close match between the luminosity functions of the LSP stars and all of the stars in our sample, and that these star’s pulsation amplitudes are relatively wavelength independent. Although this is characteristic of stellar multiplicity, the large number of these variables is problematic for that explanation.

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A mid-infrared study of H\textsc{ii} regions in the Magellanic Clouds: N88 A and N160 A
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To show the importance of high-spatial resolution observations of H\textsc{ii} regions when compared with observations
obtained with larger apertures such as ISO, we present mid-infrared spectra of two Magellanic Cloud H\textsc{ii} regions, N88 A and N160 A. We obtained mid-infrared (8–13 \textmu{}m), long-slit spectra with TIMMI2 on the ESO 3.6 m telescope. These are combined with archival spectra obtained with the Infrared Spectrograph (IRS) onboard the Spitzer Space Telescope, and are compared with the low-spatial resolution ISO-SWS data. An inventory of the spectra in terms of atomic fine-structure lines and molecular bands is presented. Concerning N88 A, an isolated H\textsc{ii} region with no adjacent infrared sources, the observations indicate that the line fluxes observed by ISO-SWS and Spitzer-IRS come exclusively from the compact H\textsc{ii} region of about 3'' in diameter. This is not the case for N160 A, which has a more complex morphology. We have spectroscopically isolated for the first time the individual contributions of the three components of N160 A, two high-excitation blobs, A1 and A2, and the young stellar object N160 A-IR. In addition, extended [S\textsc{iv}] emission is observed with TIMMI2 and is most likely associated with the central star cluster located between A1 and A2. We show the value of these high-spatial resolution data in determining source characteristics, such as the degree of ionization of each high-excitation blob or the bolometric luminosity of the YSO. This luminosity ($2 \times 10^5 \, L_\odot$) is about one order of magnitude lower than previously estimated. For each high-excitation blob, we also determine the electron density and the elemental abundances of Ne, S, and Ar.

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X-ray and UV spectroscopy of Galactic diffuse hot gas along the LMC X-3 sight line

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We present Suzaku spectra of X-ray emission in the fields just off the LMC X-3 sight line. O\textsc{vii}, O\textsc{viii}, and Ne\textsc{ix} emission lines are clearly detected, suggesting the presence of an optically thin thermal plasma with an average temperature of $2.4 \times 10^6 \, K$. This temperature is significantly higher than that inferred from existing X-ray absorption line data obtained with Chandra grating observations of LMC X-3, strongly suggesting that the gas is not isothermal. We then jointly analyze these data to characterize the spatial and temperature distributions of the gas. Assuming a vertical exponential Galactic disk model, we estimate the gas temperature and density at the Galactic plane and their scale heights as $3.6 (2.9, 4.7) \times 10^6 \, K$ and $1.4 (0.3, 3.4) \times 10^{-3} \, cm^{-3}$, and $1.4 (0.2, 5.2) \, kpc$ and $2.8 (1.0, 6.4) \, kpc$, respectively. This characterization can account for all the O\textsc{vi} line absorption, as observed in a FUSE spectrum of LMC X-3, but only predicts less than one tenth of the O\textsc{vi} line emission intensity typically detected at high Galactic latitudes. The bulk of the O\textsc{vi} emission most likely arises at interfaces between cool and hot gases.

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In search of RR Lyrae type stars in eclipsing binary systems.

OGLE 052218.07–692827.4: an optical blend

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During the OGLE-2 operation, Soszyński et al. (2003) found 3 LMC candidates for an RR Lyr-type component in an
eclipsing binary system. Two of those have orbital periods that are too short to be physically plausible and hence have to be optical blends. For the third, OGLE052218.07—692827.4, we developed a model of the binary that could host the observed RR Lyr star. After being granted HST/WFPC2 time, however, we were able to resolve 5 distinct sources within a 1.3" region that is typical of OGLE resolution, proving that OGLE052218.07—692827.4 is also an optical blend. Moreover, the putative eclipsing binary signature found in the OGLE data does not seem to correspond to a physically plausible system; the source is likely another background RR Lyr star. There are still no RR Lyr stars discovered so far in an eclipsing binary system.

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Suzaku Observation of 30 Dor C: A Supernova Remnant with the Largest Non-Thermal Shell
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This paper reports on the Suzaku results of thermal and non-thermal features of 30 Dor C, a supernova remnant (SNR) in a superbubble of the Large Magellanic Cloud (LMC). The west rim exhibits a non-thermal X-ray spectrum with no thermal component. A single power-law model is rejected but a power-law model with spectral cutoff is accepted. The cutoff frequency of \((3 - 7) \times 10^{17}\) Hz is the highest among the shell type SNRs like SN1006 \((\sim 6 \times 10^{16}\) Hz), and hence 30 Dor C would be the site of the highest energy accelerator of the SNR shock. The southeast (SE) and northeast (NE) rims have both the thermal and non-thermal components. The thin-thermal plasmas in the both rims are in collisional ionization equilibrium state. The electron temperature of the plasma in the SE rim \((kT_e \sim 0.7\) keV) is found to be higher than the previously reported value. The power-law index from SE is nearly the same as, while that from the NE is larger than that of the West rim. The SNR age would be in the range of \((4 - 20) \times 10^3\) yr. Thus, 30 Dor C is likely to be the oldest shell-like SNR with non-thermal emission.

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Evolution of stellar structure in the Small Magellanic Cloud
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The projected distribution of stars in the Small Magellanic Cloud (SMC) from the Magellanic Clouds Photometric Survey is analysed. Stars of different ages are selected via criteria based on V magnitude and V—I colour, and the degree of ‘grouping’ as a function of age is studied. We quantify the degree of structure using the two-point correlation function and a method based on the Minimum Spanning Tree and find that the overall structure of the SMC is evolving from a high degree of sub-structure at young ages \((\sim 10\) Myr) to a smooth radial density profile. This transition is gradual and at \(\sim 75\) Myr the distribution is statistically indistinguishable from the background SMC distribution. This time-scale corresponds to approximately the dynamical crossing time of stars in the SMC. The spatial positions of the star clusters in the SMC show a similar evolution of spatial distribution with age. Our analysis suggests that stars form with a high degree of (fractal) sub-structure, probably imprinted by the turbulent nature of the gas from which
they form, which is erased by random motions in the galactic potential on a time-scale of a galactic crossing time.

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**Ionization Cone in the X-ray Binary LMC X-1**

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In an earlier paper, we presented the first evidence for a bow-shock nebula surrounding the X-ray binary LMC X-1 on a scale of ~15 pc, which we argued was powered by a jet associated with an accretion disk. We now present the first evidence for an ionization cone extending from an X-ray binary, a phenomenon only seen to date in active galactic nuclei (AGN). The ionization cone, detected in the He ıı4686/Hβ and [O ııı]5007/Hβ line ratio maps, aligns with the direction of the jet inferred from the bow-shock nebula. The cone has an opening angle ~ 45° and radial extent ~3.8 pc. Since the He ıı emission cannot be explained by the companion O star, the gas in the ionization cone must be exposed to the ‘naked’ accretion disk, thereby allowing us to place constraints on the unobservable ionizing spectrum. The energetics of the ionization cone give unambiguous evidence for an ”ultraviolet – soft X-ray” (XUV) excess in LMCX-1. Any attempt to match the hard X-ray spectrum (> 1 keV) with a conventional model of the accretion disk fails to account for this XUV component. We propose two likely sources for the observed anisotropy: (1) obscuration by a dusty torus, or (2) a jet-blown hole in a surrounding envelope of circumstellar absorbing material. We discuss the implications of our discovery in the context of the mass-scaling hypothesis for accretion onto black holes and suggest avenues for future research.

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**On the Enhancement of Mass Loss in Cepheids Due to Radial Pulsation. II. The Effect of Metallicity**

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It has been observed that Cepheids in the Magellanic Clouds have lower masses for the same luminosity than those in the Milky Way. The model, from Neilson & Lester (2008), of pulsation-driven mass loss for Cepheids is applied to theoretical models of Cepheids with metallicity consistent with the Milky Way and Large and Small Magellanic Clouds. The mass-loss model is analyzed using the metallicity correction of the Period–Luminosity relation to compare the ratio of mass loss of Cepheids with lower metallicity to that of Cepheids with solar metallicity. It is determined that mass loss may be larger for the lower metallicity Cepheids, counterintuitive to radiative driving estimates. Also the mass-loss rates of theoretical Cepheid models are found to be up to $5 \times 10^{-9}$ for Galactic Cepheids, $5 \times 10^{-8}$ for Large Magellanic Cloud Cepheids, and $2 \times 10^{-7}$ M⊙ yr⁻¹ for Small Magellanic Cloud Cepheids. It is argued that mass loss increases as metallicity decreases for Cepheids with periods less than 20 days and that mass loss decreases for longer periods. Assuming dust forms in the wind of a Cepheid at some distance, the infrared excess of the models is computed, finding the infrared brightness is approximately a magnitude larger due to mass loss. The infrared magnitudes are compared to recently published Period–Luminosity relations as a test of our predictions.

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Exploring the Small Magellanic Cloud to the Faintest X-ray Fluxes: 
Source Catalog, Timing and Spectral Analysis

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We present the results of a pair of 100 ksec Chandra observations in the Small Magellanic Cloud to survey HMXBs, stars and LMXBs/CVs down to $L_X = 10^{32}$ erg s\textsuperscript{-1}. The two SMC deep-fields are located in the most active star forming region of the bar. Deep Field-1 is positioned at the most pulsar-rich location (identified from previous surveys). Two new pulsars were discovered in outburst: CXO J004929.7$-$731058 ($P = 894$ s), CXO J005252.2$-$721715 ($P = 326$ s), and 14 candidate quiescent pulsars were identified from their timing and spectral properties. Out of 12 previously known pulsars in the fields, 9 were detected, with pulsations seen in five of them. This demonstrates for the first time that a significant fraction (at least 60\%) of these systems have appreciable accretion driven X-ray emission during quiescence. Two known pulsars in the field were not detected, with an upper limit of $L_X < 5 \times 10^{32}$. The full catalog of 394 point-sources is presented along with detailed analyses of timing and spectral properties. Future papers will report associated observations obtained with HST and Magellan to identify optical counterparts.

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Near-Infrared Photometry of four stellar clusters in the Small Magellanic Cloud

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We present high-quality J, H and K\textsubscript{s} photometry of four Small Magellanic Cloud stellar clusters with intermediate ages in the 1–7 Gyr range (namely NGC 339, 361, 416 and 419). We obtained deep Color-Magnitude Diagrams to study the evolved sequences and providing a detailed census of the Red Giant Branch (RGB), Asymptotic Giant Branch (AGB) and Carbon star populations in each cluster and their contribution to the total cluster light. We find that in the $\sim$5–7 Gyr old clusters AGB stars account for 6 light in K\textsubscript{s}-band, Carbon stars are lacking and RGB stars account for $\sim$45\% of the total bolometric luminosity. These empirical findings are in good agreement with the theoretical predictions. Finally, we derived photometric metallicities computed by using the properties of the RGB and finding an iron content of [Fe/H]$=-1.18$, $-1.08$, $-0.99$ and $-0.96$ dex for NGC 339, 361, 416 and 419 respectively.

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Abundances and Isotope Ratios in the Magellanic Clouds: The Star Forming Environment of N 113

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With the goal of deriving the physical and chemical conditions of star forming regions in the Large Magellanic Cloud...
(LMC), a spectral line survey of the prominent star forming region N113 is presented. The observations cover parts of the frequency range from 85 GHz to 357 GHz and include 63 molecular transitions from a total of 16 species, among them spectra of rare isotopologues. Maps of selected molecular lines as well as the 1.2 mm continuum distribution are also presented. Molecular abundances in the core of the complex are consistent with a photon dominated region (PDR) in a nitrogen deficient environment. While CO shows optical depths of order \( \tau \sim 10 \), \(^{13}\)CO is optically thin. The most prominent lines of CS, HCN, and HCO\(^+\) show signs of weak saturation (\( \tau \sim 0.5 \)). Densities range from \( 5 \times 10^3 \) cm\(^{-3}\) for CO to almost \( 10^4 \) for CS, HCN, and a few other species, indicating that only the densest regions provide sufficient shielding even for some of the most common species. An ortho- to para-H\(_2\)CO ratio of \( \sim 3 \) hints at H\(_2\)CO formation in a warm (\( \gtrsim 40\) K) environment. Isotope ratios are \(^{12}\)C/\(^{13}\)C \( \sim 49 \pm 5\), \(^{16}\)O/\(^{18}\)O \( \sim 2000 \pm 250\), \(^{18}\)O/\(^{17}\)O \( \sim 1.7 \pm 0.2\) and \(^{32}\)S/\(^{34}\)S \( \sim 15\). Agreement with data from other star forming clouds shows that the gas is well mixed in the LMC. The isotope ratios do not only differ from those seen in the Galaxy. They also do not form a continuation of the trends observed with decreasing metallicity from the inner to the outer Galaxy. This implies that the outer Galaxy, even though showing an intermediate metallicity, is not providing a transition zone between the inner Galaxy and the metal poor environment of the Magellanic Clouds. A part of this discrepancy is caused by differences in the age of the stellar populations in the outer Galaxy and the LMC. While, however, this scenario readily explains measured carbon and oxygen isotope ratios, nitrogen and sulfur still lack a self-consistent interpretation.

**Towards an Accurate Determination of Parameters for Very Massive Stars: the Eclipsing Binary LMC-SC1-105**

**Alicez Z. Bonanos**

This paper presents a photometric and spectroscopic study of the bright blue eclipsing binary LMC-SC1-105, selected from the OGLE catalog as a candidate host of very massive stars (\( \gtrsim 30\) M\(_{\odot}\)). The system is found to be a double-lined spectroscopic binary, which indeed contains massive stars. The masses and radii of the components are \( M_1 = 30.9 \pm 1.0\) M\(_{\odot}\), \( M_2 = 13.0 \pm 0.7\) M\(_{\odot}\), and \( R_1 = 15.1 \pm 0.2\) R\(_{\odot}\), \( R_2 = 11.9 \pm 0.2\) R\(_{\odot}\), respectively. The less massive star is found to be filling its Roche lobe, indicating the system has undergone mass-transfer. The spectra of LMC-SC1-105 display the Struve-Sahade effect, with the HeI lines of the secondary appearing stronger when it is receding and causing the spectral types to change with phase (O8+O8 to O7+O8.5). This effect could be related to the mass-transfer in this system. To date, accurate (\( \leq 10\%\)) fundamental parameters have only been measured for 15 stars with masses greater than 30 M\(_{\odot}\), with the reported measurements contributing valuable data on the fundamental parameters of very massive stars at low metallicity. The results of this work demonstrate that the strategy of targeting the brightest blue stars in eclipsing binaries is an effective way of studying very massive stars.

**AKARI near-infrared spectroscopy: detection of H\(_2\)O and CO\(_2\) ices toward Young Stellar Objects in the Large Magellanic Cloud**

**Takashi Shimonishi**

This paper presents the first results of AKARI Infrared Camera near-infrared spectroscopic survey of the Large Magellanic
Cloud (LMC). We detected absorption features of the H$_2$O ice 3.05 $\mu$m and the CO$_2$ ice 4.27 $\mu$m stretching mode toward seven massive young stellar objects (YSOs). These samples are for the first time spectroscopically confirmed to be YSOs.

We used a curve-of-growth method to evaluate the column densities of the ices and derived the CO$_2$/H$_2$O ratio to be 0.45 ± 0.17. This is clearly higher than that seen in Galactic massive YSOs (0.17 ± 0.03). We suggest that the strong ultraviolet radiation field and/or the high dust temperature in the LMC may be responsible for the observed high CO$_2$ ice abundance.

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**Frequency analysis of Cepheids in the Large Magellanic Cloud. New types of classical Cepheid pulsators**

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We have performed a detailed systematic search for multiperiodicity in the Population I Cepheids of the Large Magellanic Cloud. In this process we have identified for the first time several new types of Cepheid pulsational behaviour. We have found two triple-mode Cepheids pulsating simultaneously in the first three radial overtones. In 9% of the first overtone Cepheids we have detected weak, but well resolved secondary periodicities. They appear either very close to the primary pulsation frequency or at a much higher frequency with a characteristic period ratio of 0.60 ± 0.04. In either case, the secondary periodicities must correspond to nonradial modes of oscillation. This result presents a major challenge to the theory of stellar pulsations, which predicts that such modes should not be exited in Cepheid variables. Nonradial modes have also been found in three of the fundamental/first overtone double-mode Cepheids, but no such oscillations have been detected in single mode Cepheids pulsating in the fundamental mode.

In 19% of double-mode Cepheids pulsating in the first two radial overtones (FO/SO type) we have detected a Blazhko-type periodic modulation of amplitudes and phases. Both modes are modulated with a common period, which is always longer than 700 days. Variations of the two amplitudes are anticorrelated and maximum of one amplitude always coincides with minimum of the other. We have compared observations of modulated FO/SO Cepheids with predictions of theoretical models of the Blazhko effect, showing that currently most popular models cannot account for properties of these stars. We propose that Blazhko effect in FO/SO Cepheids can be explained by a nonstationary resonant interaction of one of the radial modes with another, perhaps nonradial, mode of oscillations.

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**BS 196: an old star cluster far from the SMC main body**

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We present B and V photometry of the outlying SMC star cluster BS 196 with the 4.1-m SOAR telescope. The photometry is deep (to V ~ 25) showing ~ 3 mag below the cluster turnoff point (TO) at $M_V = 2.5$ (1.03 M$_\odot$). The cluster is located at the SMC distance. The CMD and isochrone fittings provide a cluster age of 5.0 ± 0.5 Gyr, indicating that this is one of the 12 oldest clusters so far detected in the SMC. The estimated metallicity is [Fe/H] = −1.68 ± 0.10.
The structural analysis gives by means of King profile fittings a core radius $R_c = 8.7 \pm 1.1$ arcsec ($2.66 \pm 0.14$ pc) and a tidal radius $R_t = 69.4 \pm 1.7$ arcsec ($21.2 \pm 1.2$ pc). BS 196 is rather loose with a concentration parameter $c = 0.90$. With $M_V = -1.89 \pm 0.39$, BS 196 belongs to the class of intrinsically fainter SMC clusters, as compared to the well-known populous ones, which starts to be explored.

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**Discovery of Extreme Carbon Stars in the LMC**

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Using *Spitzer* IRAC and MIPS observations of the Large Magellanic Cloud, we have identified 13 objects that have extremely red mid-IR colors. Follow-up *Spitzer* IRS observations of seven of these sources reveal varying amounts of SiC and C\(_2\)H\(_2\) absorption as well as the presence of a broad MgS feature in at least two cases, indicating that these are extreme carbon stars. Preliminary estimates find these objects have luminosities of $4-11 \times 10^3$ L\(_\odot\) and preliminary model fitting gives mass-loss rates between $4 \times 10^{-5}$ and $2 \times 10^{-4}$ M\(_\odot\) yr\(^{-1}\), higher than any known carbon-rich AGB star in the LMC. These spectral and physical properties require careful reconsideration of dust condensation and mass-loss processes for carbon stars in low metallicity environments.

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**Implications of Recent Measurements of the Milky Way Rotation for the Orbit of the Large Magellanic Cloud**

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We examine the implications of recent measurements of the Milky Way (MW) rotation for the trajectory of the Large Magellanic Cloud (LMC). The $\sim 14 \pm 6\%$ increase in the MW circular velocity relative to the IAU standard of 220 km s\(^{-1}\) changes the qualitative nature of the inferred LMC orbit. Instead of the LMC being gravitationally unbound, as has been suggested based on a recent measurement of its proper motion, we find that the past orbit of the LMC is naturally confined within the virial boundary of the MW. The orbit is not as tightly bound as in models derived before the LMC proper motion was measured.

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Star cluster evolution in the Magellanic Clouds revisited

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The evolution of star clusters in the Magellanic Clouds has been the subject of significant recent controversy, particularly regarding the importance and length of the earliest, largely mass-independent disruption phase (referred to as ‘infant mortality’). Here, we take a fresh approach to the problem, using a large, independent, and homogeneous data set of $UBVR$ imaging observations, from which we obtain the cluster age and mass distributions in both the Large and Small Magellanic Clouds (LMC, SMC) in a self-consistent manner. We conclude that the (optically selected) SMC star cluster population has undergone at most $\lesssim$30\% (1\sigma) infant mortality between the age range from about 3–10 Myr, to that of approximately 40–160 Myr. We rule out a 90\% cluster mortality rate per decade of age (for the full age range up to $10^{10}$ yr) at a $>6\sigma$ level. Using a simple approach, we derive a ‘characteristic’ cluster disruption time-scale for the cluster population in the LMC that implies that we are observing the initial cluster mass function. Preliminary results suggest that the LMC cluster population may be affected by < 10\% infant mortality.


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Chemical evolution of the Magellanic Clouds based on planetary nebulae

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Planetary nebulae (PN) are an essential tool in the study of the chemical evolution of the Milky Way and galaxies of the Local Group, particularly the Magellanic Clouds. In this work, we present some recent results on the determination of chemical abundances from PN in the Large and Small Magellanic Clouds, and compare these results with data from our own Galaxy and other galaxies in the Local Group. As a result of our continuing long term program, we have a large database comprising about 300 objects for which reliable abundances of several elements from He to Ar have been obtained. Such data can be used to derive constraints to the nucleosynthesis processes in the progenitor stars in galaxies of different metallicities. We also investigate the time evolution of the oxygen abundances in the SMC by deriving the properties of the PN progenitor stars, which include their masses and ages. We have then obtained an age-metallicity relation taking into account both oxygen and [Fe/H] abundances. We show that these results have an important consequence on the star formation rate of the SMC, in particular by suggesting a star formation burst in the last 2–3 Gyr.


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and from http://www.astro.iag.usp.br/~maciel
Conference Summary: Magellanic System — Stars, Gas and Galaxies

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We provide a brief overview of some of the issues that came out of the IAU 256 symposium on the Magellanic System (http://www.astro.keele.ac.uk/iaus256).

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Modeling Mass-Loss and Infrared Excess in Large Magellanic Cloud Cepheids

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The purpose of this preliminary work is to determine if Large Magellanic Cloud (LMC) Cepheids have stellar winds. If a Cepheid undergoes mass loss then at some distance from the star, a fraction of the gas becomes dust, which causes an infrared excess. Mass loss is tested using OGLE II optical observations and SAGE infrared observations for a sample of 488 Cepheids. The resultant mass-loss rates range from $10^{-12}$ to $10^{-7}$ M$_{\odot}$ yr$^{-1}$. Using the mass-loss model we compute infrared stellar luminosities for the sample of Cepheids and compare predicted infrared PL relations with observed relations. The predicted relations not only vary from the observed relations, implying mass loss plays a significant role, but also show evidence for non-linearity. It is determined that mass loss is important for LMC Cepheids.

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The WFI H\$\alpha$ spectroscopic survey of the Magellanic Clouds: Be stars in SMC open clusters

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At low metallicity, B-type stars show lower loss of mass and, therefore, angular momentum so that it is expected that there are more Be stars in the Magellanic Clouds than in the Milky Way. However, till now, searches for Be stars were only performed in a very small number of open clusters in the Magellanic Clouds. Using the ESO/WFI in its slitless spectroscopic mode, we performed a Halpha survey of the Large and Small Magellanic Cloud. Eight million low-resolution spectra centered on Halpha were obtained. For their automatic analysis, we developed the ALBUM code. Here, we present the observations, the method to exploit the data and first results for 84 open clusters in the
SMC. In particular, cross-correlating our catalogs with OGLE positional and photometric data, we classified more than 4000 stars and were able to find the B and Be stars in them. We show the evolution of the rates of Be stars as functions of area density, metallicity, spectral type, and age.

Available from arXiv:0809.2198

ZAMS rotational velocities of Be/Oe stars and LGRBs progenitors in the Magellanic Clouds

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The Large and Small Magellanic Clouds are privileged environments to perform tests of theoretical predictions at low metallicity on rotational velocities and stellar evolution. According to theoretical predictions, the rotational velocities of B-type stars are expected to be higher in low metallicity (LMC/SMC) than in high metallicity (MW) environments. To verify the models, we observed with the VLT-FLAMES 523 B and Be stars, which form, at the moment, the largest observed sample of these kind of objects in the MCs. We first determined the stellar fundamental parameters and we found that B and Be stars rotate faster in the MCs than in the MW. We also determined the first distribution of the average ZAMS rotational velocities versus the mass of Be stars. These results indicate that the appearance of Be stars is mass-, metallicity-, stellar evolution-, and star-formation regions-dependant. Moreover, the recent models of Long Gamma Ray Bursts progenitors foresee possible LGRBs progenitors at the SMC’s metallicity. We confront these models with the observed (ZAMS rotational velocities, masses) distributions of the fastest rotators (Be and Oe stars) in our sample. Furthermore, we compare the corresponding predicted rates from our study with observed rates of LGRBs.

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Variability of B and Be stars in the LMC/SMC: binaries and pulsations

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To study the variability of the 523 B and Be stars observed in the Magellanic clouds with the VLT-FLAMES, we cross-matched the stars of our sample with the photometric database MACHO, which provides for each star an 8 years lightcurve. We searched for long, medium, and short-term periodicity and found the eclipsing binaries in our sample. For these stars, combining, spectroscopy and photometry, we were able to provide information on several systems of stars (systemic velocities, ratios of masses, etc). We also present the ratios of B-binaries to B-non binaries in the LMC/SMC in comparison with the MW. Note that this ratio is also an important issue to understand the mechanism of star-formation at low metallicity. We also found the first multiperiodic B and Be stars in the SMC, in particular the first SMC βCep and SPB, while, according to the models, pulsations were not foreseen in low metallicity environments, i.e. typically in the SMC. Our results show that the instability strips are shifted towards
higher temperatures in comparison with the Milky Way’s strips of pulsating B-type stars. By the fact that we found more pulsating Be stars than pulsating B stars in the SMC, it seems that the fast rotation favours the presence of pulsations. However, the ratio of pulsating B-type stars to ”non”-pulsating B-type stars at low metallicity is lower than at high metallicity.

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Line of sight depth of the Large and Small Magellanic Clouds

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We used the red clump stars from the Optical Gravitational Lensing Experiment (OGLE II) survey and the the Magellanic Cloud Photometric Survey (MCPS), to estimate the line of sight depth. The observed dispersion in the magnitude and colour distribution of red clump stars is used to estimate the line of sight depth, after correcting for the contribution due to other effects. This dispersion due to depth, has a range from minimum dispersion that can be estimated, to 0.46 mag (a depth of 500 pc to 10.44 Kpc), in the LMC. In the case of SMC, the dispersion ranges from minimum dispersion to 0.35 magnitude (a depth of 665 pc to 9.53 Kpc). The thickness profile of LMC bar indicates that it is flared. The average depth in the bar region is 4.0±1.4 kpc. The halo of the LMC (using RR Lyrae stars) is found to have larger depth compared to the disk/bar, which supports the presence of inner halo for the LMC. The large depth estimated for the LMC bar and the disk suggests that the LMC might have had minor mergers. In the case of SMC, the bar depth (4.90±1.23 Kpc) and the disk depth (4.23±1.48 Kpc) are found to be within the standard deviations. We find evidence for increase in depth near the optical center (up to 9 kpc). On the other hand, the estimated depth for the halo (RR Lyrae stars) and disk (RC stars) for the bar region of the SMC is found to be similar. Thus, increased depth and enhanced stellar as well as H I density near the optical center suggests that the SMC may have a bulge.

Available from arXiv:0809.2637

Pulsating B and Be stars in the Magellanic Clouds

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Stellar pulsations in main-sequence B-type stars are driven by the κ-mechanism due to the Fe-group opacity bump. The current models do not predict the presence of instability strips in the B spectral domain at very low metallicities. As the metallicity of the Magellanic Clouds (MC) has been measured to be around $Z = 0.002$ for the Small Magellanic Cloud (SMC) and $Z = 0.007$ for the Large Magellanic Cloud (LMC), they constitute a very suitable objects to test these predictions. The aim of this work is to investigate the existence of B-type pulsators at low metallicities, searching for short-term periodic variability in a large sample of B and Be stars from the MC with accurately determined fundamental astrophysical parameters.

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New distance and depth estimates from observations of eclipsing binaries in the SMC

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A sample of 33 eclipsing binaries observed in a field of the SMC with FLAMES@VLT is presented. The radial velocity curves obtained, together with existing OGLE light curves, allowed the determination of all stellar and orbital parameters of these binary systems. The mean distance modulus of the observed part of the SMC is 19.05, based on the 26 most reliable systems. Assuming an average error of 0.1 mag on the distance modulus to an individual system, and a gaussian distribution of the distance moduli, we obtain a 2-σ depth of 0.36 mag or 10.6 kpc. Some results on the kinematics of the binary stars and of the H II gas are also given.

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The WFI Hα spectroscopic survey

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This document presents the results from our spectroscopic survey of Hα emitters in galactic and SMC open clusters with the ESO Wide Field Imager in its slitless spectroscopic mode. First of all, for the galactic open cluster NGC6611, in which, the number and the nature of emission line stars is still the object of debates, we show that the number of true circumstellar emission line stars is small. Second, at low metallicity, typically in the Small Magellanic Cloud, B-type stars rotate faster than in the Milky Way and thus it is expected a larger number of Be stars. However, till now, search for Be stars was only performed in a very small number of open clusters in the Magellanic Clouds. Using the ESO/WFI in its slitless spectroscopic mode, we performed a Hα survey of the Small Magellanic Cloud. 3 million low-resolution spectra centered on Hα were obtained in the whole SMC. We present the method to exploit the data and first results for 84 open clusters in the SMC about the ratios of Be stars to B stars.

Poster contribution, published in SF2A2008
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The Binarity of the Clouds and the Formation of the Magellanic Stream

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The HST proper motion (PM) measurements of the Clouds have severe implications for their interaction history with the Milky Way (MW) and with each other. The Clouds are likely on their first passage about the MW and the SMC’s orbit about the LMC is better described as quasi-periodic rather than circular. Binary L/SMC orbits that satisfy observational constraints on their mutual interaction history (e.g. the formation of the Magellanic Bridge during a
collision between the Clouds ~300 Myr ago) can be located within 1σ of the mean PMs. However, these binary orbits are not co-located with the Magellanic Stream (MS) when projected on the plane of the sky and the line-of-sight velocity gradient along the LMC’s orbit is significantly steeper than that along the MS. These combined results ultimately rule out a purely tidal origin for the MS: tides are ineffective without multiple pericentric passages and can neither decrease the velocity gradient nor explain the offset stream in a polar orbit configuration. Alternatively, ram pressure stripping of an extended gaseous disk may naturally explain the deviation. The offset also suggests that observations of the little-explored region between RA 21h and 23h are crucial for characterizing the full extent of the MS.

Available from arXiv:0809.4265

The Magellanic Group and the Seven Dwarfs

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The Magellanic Clouds were the largest members of a group of dwarf galaxies that entered the Milky Way (MW) halo at late times. This group, dominated by the LMC, contained ~4% of the mass of the Milky Way prior to its accretion and tidal disruption, but ~70% of the known dwarfs orbiting the MW. Our theory addresses many outstanding problems in galaxy formation associated with dwarf galaxies. First, it can explain the planar orbital configuration populated by some dSphs in the MW. Second, it provides a mechanism for lighting up a subset of dwarf galaxies to reproduce the cumulative circular velocity distribution of the satellites in the MW. Finally, our model predicts that most dwarfs will be found in association with other dwarfs. The recent discovery of Leo V (Belokurov et al. 2008), a dwarf spheroidal companion of Leo IV, and the nearby dwarf associations supports our hypothesis.

Available from arXiv:0809.3787

New Analysis of the Proper Motions of the Magellanic Clouds using HST/WFPC2

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In HST Cycles 11 and 13 we obtained two epochs of ACS/HRC data for fields in the Magellanic Clouds centered on background quasars. We used these data to determine the proper motions of the LMC and SMC to better than 5% and 15% respectively. The results had a number of unexpected implications for the Milky Way-LMC-SMC system. The implied three-dimensional velocities were larger than previously believed and close to the escape velocity in a standard 10¹² M☉ Milky Way dark halo, implying that the Clouds may be on their first passage. Also, the relative velocity between the LMC and SMC was larger than expected, leaving open the possibility that the Clouds may not be bound to each other. To further verify and refine our results we requested an additional epoch of data in Cycle 16 which is being executed with WFPC2/PC due to the failure of ACS. We present the results of an ongoing analysis of these WFPC2 data which indicate good consistency with the two-epoch results.

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The Chemical Enrichment History of the Magellanic Clouds Field Populations

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We report the results of our project devoted to study the chemical enrichment history of the field population in the Magellanic Clouds using CaII triplet spectroscopy.

Available from arXiv:0809.4179

Review Papers

X-ray stellar population of the LMC

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In the study of stars, the high energy domain occupies a place of choice, since it is the only one able to directly probe the most violent phenomena: indeed, young pre-main sequence objects, hot massive stars, or X-ray binaries are best revealed in X-rays. However, previously available X-ray observatories often provided only crude information on individual objects in the Magellanic Clouds. The advent of the highly efficient X-ray facilities XMM-Newton and Chandra has now dramatically increased the sensitivity and the spatial resolution available to X-ray astronomers, thus enabling a fairly easy determination of the properties of individual sources in the LMC.

Available from arXiv:0808.3924

The Properties of Early-type Stars in the Magellanic Clouds

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The past decade has witnessed impressive progress in our understanding of the physical properties of massive stars in the Magellanic Clouds, and how they compare to their cousins in the Galaxy. I summarise new results in this field, including evidence for reduced mass-loss rates and faster stellar rotational velocities in the Clouds, and their present-day compositions. I also discuss the stellar temperature scale, emphasizing its dependence on metallicity across the entire upper-part of the Hertzsprung-Russell diagram.

Available from arXiv:0809.0852
Kinematical Structure of the Magellanic System

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We review our understanding of the kinematics of the LMC and the SMC, and their orbit around the Milky Way. The line-of-sight velocity fields of both the LMC and SMC have been mapped with high accuracy using thousands of discrete traces, as well as H\textsubscript{i} gas. The LMC is a rotating disk for which the viewing angles have been well-established using various methods. The disk is elliptical in its disk plane. The disk thickness varies depending on the tracer population, with V/sigma ranging from 2–10 from the oldest to the youngest population. For the SMC, the old stellar population resides in a spheroidal distribution with considerable line-of-sight depth and low V/\sigma. Young stars and H\textsubscript{i} gas reside in a more irregular rotating disk. Mass estimates based on the kinematics indicate that each Cloud is embedded in a dark halo. Proper motion measurements with HST show that both galaxies move significantly more rapidly around the Milky Way than previously believed. This indicates that for a canonical 10\textsuperscript{12} M\odot Milky Way the Clouds are only passing by us for the first time. Although a higher Milky Way mass yields a bound orbit, this orbit is still very different from what has been previously assumed in models of the Magellanic Stream. Hence, much of our understanding of the history of the Magellanic System and the formation of the Magellanic Stream may need to be revised. The accuracy of the proper motion data is insufficient to say whether or not the LMC and SMC are bound to each other, but bound orbits do exist within the proper motion error ellipse.


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