THE MAGELLANIC CLOUDS NEWSLETTER
An electronic exchange on Magellanic Clouds research

Edited by Eva K. Grebel and You-Hua Chu
mcnews@astro.uiuc.edu
http://www.astro.uni-bonn.de/~mcnews/

No. 52 February 18, 2001

CONTENTS
Abstracts of 9 refereed papers 1
Meeting announcement 7

Abstracts of Refereed Papers

Observations of the Interstellar Medium in the Magellanic Bridge

N. Lehner¹, K. R. Sembach², P. L. Dufton¹, W. R. J. Rolleston¹ and F. P. Keenan¹
¹ Department of Pure and Applied Physics, The Queen’s University of Belfast, Belfast, BT7 1NN, Northern Ireland
² The Johns Hopkins University, Dept. of Physics and Astronomy, 3400 N. Charles Street, Baltimore, MD 21218, USA
³ Present address: The Johns Hopkins University, Baltimore, MD 21218, USA, nl@pha.jhu.edu

We present ultraviolet and optical spectra of DR1388, a young star in the Magellanic Bridge, a region of gas between the Small and Large Magellanic Clouds. The data have signal-to-noise ratios of 20–45 and a spectral resolution of 6.5 km s⁻¹. Interstellar absorption by the Magellanic Bridge at vₐₐ₇ₙ ≈ 200 km s⁻¹ is visible in the lines of C i, C ii, C iii, C iv, N i, O i, Al ii, Si ii, Si iii, Si iv, S ii, Ca ii, Fe ii, and Ni ii. The relative gas-phase abundances of C ii, N i, O i, Al i, Si ii, Fe ii, and Ni ii with respect to S ii are similar to those found in Galactic halo clouds, despite a significantly lower metallicity in the Magellanic Bridge. The higher ionization species in the cloud have a column density ratio N(C⁺³)/N(Si⁺³) ~ 1.9, similar to that inferred for collisionally ionized Galactic cloud interfaces at temperatures ~ 10⁵ K. We identify sub-structure in the stronger interstellar lines, with a broad component (FWHM ~ 20 km s⁻¹) at ~ 179 km s⁻¹ and a sharp component (FWHM ~ 11 km s⁻¹) at 198 km s⁻¹. The abundance analysis for these clouds indicates that the feature at 198 km s⁻¹ consists of a low electron density, mainly neutral gas that may be associated with an interface responsible for the highly ionized gas. The 179 km s⁻¹ cloud consists of warmer, lower density gas that is partially ionized.

Velocity and Density Spectra of the Small Magellanic Cloud

S. Stanimirović1 and A. Lazarian2

1 Arecibo Observatory, NAIC/Cornell University, HC 3 Box 53995, Arecibo, Puerto Rico 00612
2 University of Wisconsin, 475 North Charter Street, 5534 Sterling Hall, Madison, Wisconsin 53706

This paper reports results on the statistical analysis of HI turbulence in the Small Magellanic Cloud (SMC). We combine 21 cm channel maps, obtained with the Australia Telescope Compact Array and the Parkes telescope, and analyze the spectrum of observed intensity fluctuations as a function of the velocity slice thickness. We confirm predictions by Lazarian & Pogosyan (2000) on the change of the power law index and establish the spectra of 3-D density and velocity. The obtained spectral indices, −3.3 and −3.4, are slightly more shallow than the predictions for the Kolmogorov spectrum. This contrasts to the predictions for the shock-type spectra that are steeper than the Kolmogorov one. The nature of the energy injection in the SMC is unclear as no distinct energy injection scales are observed up to the entire scale of the SMC.

Accepted by: Astrophysical Journal Letters
For preprints, contact sstanimi@naic.edu

FUSE Observations of Interstellar Gas toward the SMC Star Sk 108


1 University of Chicago, Department of Astronomy & Astrophysics, 5640 S. Ellis Ave., Chicago, IL 60637, USA
2 Enrico Fermi Institute, 5640 S. Ellis Ave., Chicago, IL 60637, USA
3 Department of Physics and Astronomy, Johns Hopkins University 3400 N. Charles St., Baltimore, MD 21218, USA
4 Princeton University Observatory, Princeton, NJ 08544, USA
5 Département d’Astrophysique Relativiste et de Cosmologie, UMR-8629 CNRS, Observatoire de Paris-Meudon, Place Jules Janssen, F-92195 Meudon, France
6 Department of Astronomy, University of Wisconsin, 475 N. Charter St., Madison, WI 53706, USA
7 Center for Astrophysics and Space Astronomy, Department of Astrophysical and Planetary Sciences, University of Colorado, Campus Box 389, Boulder, CO 80309, USA
8 Laboratory for Astronomy and Solar Physics, NASA Goddard Space Flight Center, Code 811, Greenbelt, MD 20771, USA
9 Institut d’Astrophysique de Paris, CNRS, 98 bis Boulevard Arago, F-75014 Paris, France

We discuss the interstellar absorption lines found in FUSE spectra of the Wolf-Rayet binary Sk 108, located in the northeastern part of the main “bar” of the Small Magellanic Cloud. The spectra cover the wavelength range 988 – 1187 Å, at a resolution of about 12,000 and S/N of 20–40. We use detailed component information from higher resolution near-UV and optical spectra to model the far-UV lines of similarly distributed species. Both the Galactic and SMC gas toward Sk 108 seem to be predominantly neutral, though a significant fraction of the SMC gas is ionized. The column densities of P II, S II, and Ar I are consistent with essentially solar ratios, relative to N(2s II), in both the Galactic and SMC gas; the column density of N I remains somewhat uncertain. Molecular hydrogen is present in the Galactic gas, with properties similar to those found in low mean density Galactic
lines of sight and in the Galactic gas toward several other LMC and SMC stars. We report a tentative
detection of H$_2$ in the SMC gas for $J = 1$ and 3, with rotational level populations consistent with
an excitation temperature of order 1000 K — similar to the H$_2$ found in diffuse Galactic gas toward
ζ Pup. Strong absorption from N III, S III, and Fe III has revealed a significant ionized component,
particularly in the SMC; O VI is present, but relatively weak, especially in the Galactic gas. The
$N$(C IV)/$N$(O VI) ratio varies somewhat within the SMC — suggesting that several processes may
contribute to the observed high ion abundances.

*Submitted to: Astrophysical Journal*
*For preprints, contact chrism@borgil.uchicago.edu*

The ISM Interactions of a Magellanic Cloud LBV-candidate

Charles W. Danforth$^1$ and You-Hua Chu$^2$

$^1$ Department of Physics and Astronomy, The Johns Hopkins Univ., 3400 N. Charles St., Baltimore, MD 21218, USA
$^2$ Astronomy Department, University of Illinois, 1002 W. Green St., Urbana, IL 61801, USA

New observations of the Magellanic Cloud LBV-candidate star S119 (HD 269687) show the relationship of the star to its environs. Echelle spectroscopy and high-resolution HST imagery reveal an expanding bubble. This bubble appears in both Hα and [N II] and is noticeably brighter on the near (blue-shifted) side. The systemic velocity of both the expanding bubble and the star itself (as seen by the very broad Hα emission feature in the stellar spectrum) is $V_{hel} \approx 160$ km s$^{-1}$ whereas the velocity of the superposed LMC ISM is 250–300 km s$^{-1}$. ISM absorption features seen in FUSE spectra reveal components at both stellar and LMC velocities. Thus we conclude that S119 is located behind some substantial fraction of the LMC ISM and that the bubble is interacting strongly with the ISM in a bow shock.

*Submitted to: ApJ Letters*
*For preprints, contact danforth@pha.jhu.edu*
*Also available from the URL http://fuse.pha.jhu.edu/~danforth/s119/*

Mass-loss Predictions for O and B stars as a Function of Metallicity

Jorick S. Vink$^1$, Alex de Koter$^2$ and Henny J.G.L.M. Lamers$^1$

$^1$ Astronomical Institute, Utrecht University, P.O.Box 80000, NL-3508 TA Utrecht, The Netherlands
$^2$ Astronomical Institute “Anton Pannekoek”, University of Amsterdam, Kruislaan 403, NL-1098 SJ Amsterdam, The Netherlands

We have calculated a grid of massive star wind models and mass-loss rates for a wide range of metal abundances between $1/100 \leq Z/Z_\odot \leq 10$.

The calculation of this grid completes the Vink et al. (2000) mass-loss recipe with an additional parameter $Z$. We have found that the exponent of the power law dependence of mass loss vs. metallicity is constant in the range between $1/30 \leq Z/Z_\odot \leq 3$. The mass-loss rate scales as $\dot{M} \propto Z^{0.85} v_\infty^p$, with $p = -1.23$ for stars with $T_{\text{eff}} \gtrsim 25$ 000 K, and $p = -1.60$ for the B supergiants with $T_{\text{eff}} \lesssim 25$ 000 K. Taking also into account the metallicity dependence of $v_\infty$, using the power
law dependence \( v_{\infty} \propto Z^{0.13} \) from Leitherer et al. (1992), the overall result of mass loss as a function of metallicity can be represented by \( \dot{M} \propto Z^{0.69} \) for stars with \( T_{\text{eff}} \gtrsim 25,000 \text{ K} \), and \( \dot{M} \propto Z^{0.64} \) for B supergiants with \( T_{\text{eff}} \lesssim 25,000 \text{ K} \).

Although it is derived that the exponent of the mass loss vs. metallicity dependence is constant over a large range in \( Z \), one should be aware of the presence of bi-stability jumps at specific temperatures. Here the character of the line driving changes drastically due to recombinations of dominant metal species resulting in jumps in the mass loss. We have investigated the physical origins of these jumps and have derived formulae that combine mass loss recipes for both sides of such jumps. As observations of different galaxies show that the ratio Fe/O varies with metallicity, we make a distinction between the metal abundance \( Z \) derived on the basis of iron or oxygen lines.

Our mass-loss predictions are successful in explaining the observed mass-loss rates for Galactic and Small Magellanic Cloud O-type stars, as well as in predicting the observed Galactic bi-stability jump. Hence, we believe that our predictions are reliable and suggest that our mass-loss recipe be used in future evolutionary calculations of massive stars at different metal abundance. A computer routine to calculate mass loss is publicly available.

Accepted by: Astronomy & Astrophysics
For preprints, contact j.vink@ic.ac.uk
Also available from the URL http://astro.ic.ac.uk/~jvink/

The Nature of Sk \(-67^\circ18\) in the Large Magellanic Cloud: a Multiple System with an O3\# Component

Virpi S. Niemela\(^1\) and Wilhelm Seggewiss\(^2\) and Anthony F.J. Moffat\(^3\)

\(^1\) Observatorio Astronómico, Paseo del Bosque, 1900 La Plata, Argentina
\(^2\) Observatorium Hoher List der Universitätssternwarte Bonn, D-54550 Daun, Germany
\(^3\) Département de Physique, Université de Montréal, and Observatoire du Mont Mégantic, C.P. 6128, Succ. Centre-Ville, Montréal, Canada

We present the results of photometric and spectroscopic observations obtained between 1980 and 1996, which show that the bright star Sk \(-67^\circ18\) in the Large Magellanic Cloud (LMC) is a multiple star which contains an eclipsing binary system. Our spectra show that this is an O\# + O type binary, where the primary is probably of type O3\#. The orbital period of the eclipsing binary is almost exactly 2 days, which considerably compromises the obtaining of data with suitable phase coverage. Furthermore, from our radial velocity analysis of the spectral lines, Sk \(-67^\circ18\) appears to be a multiple system consisting of at least two pairs of short-period binaries.

Accepted by: Astronomy and Astrophysics
For preprints, contact seggewis@astro.uni-bonn.de
The MACHO Project LMC Variable Star Inventory: X. The R Coronae Borealis Stars


We report the discovery of eight new R Coronae Borealis (RCB) stars in the Large Magellanic Cloud (LMC) using the MACHO project photometry database. The discovery of these new stars increases the number of known RCB stars in the LMC to thirteen. We have also discovered four stars similar to the Galactic variable DY Per. These stars decline much more slowly and are cooler than the RCB stars. The absolute luminosities of the Galactic RCB stars are unknown since there is no direct measurement of the distance to any Galactic RCB star. Hence, the importance of the LMC RCB stars. We find a much larger range of absolute magnitudes ($M_V = -2.5$ to $-5$ mag) than inferred from the small pre-MACHO sample of LMC RCB stars. It is likely that there is a temperature - $M_V$ relationship with the cooler stars being intrinsically fainter. Cool ($\sim 5000$ K) RCB stars are much more common than previously thought based on the Galactic RCB star sample. Using the fairly complete sample of RCB stars discovered in the MACHO fields, we have estimated the likely number of RCB stars in the Galaxy to be $\sim 3,200$. The SMC MACHO fields were also searched for RCB stars but none were found.

Accepted by: ApJ (It will appear in the June 10 issue)
For preprints, contact gclayton@fenway.phys.isu.edu
Also available from the URL http://xxx.lanl.gov/abs/astro-ph/0102262

Large X-ray Flares from LMC X–4: Discovery of Milli-hertz Quasi-periodic Oscillations and QPO-modulated Pulsations

Dae-Sik Moon¹ and Stephen S. Eikenberry¹

¹ Department of Astronomy, Cornell University, Ithaca, NY 14853, USA

We report the discovery of milli-hertz (mHz) quasi-periodic oscillations (QPOs) and QPO-modulated pulsations during large X-ray flares from the high-mass X-ray binary pulsar LMC X–4 using data from the Rossi X-Ray Timing Explorer. The lightcurves of flares show that, in addition to $\sim 74$ mHz coherent pulsations, there exist two more time-varying temporal structures at frequencies of $\sim 0.65–1.35$ and $\sim 2–20$ mHz. These relatively long-term structures appear in the power density spectra as mHz QPOs and as well-developed sidebands around the coherent pulse frequency as well, indicating that the amplitudes of the coherent pulsation is modulated by those of the mHz QPOs. One interesting feature is that, while the first flare shows symmetric sidebands around the coherent pulse frequency, the second flare shows significant excess emission in the lower-frequency sidebands due to the $\sim 2–20$ mHz QPOs. We discuss the origin of the QPOs using a combination of the beat-frequency model and a modified version of the Keplerian-frequency model. According to our discussion, it seems to be possible to attribute the origin of the $\sim 0.65–1.35$ and $\sim 2–20$ mHz QPOs to the beating between the rotational frequency of the neutron star and the Keplerian frequency of large accreting clumps near the
corotation radius and to the orbital motion of clumps at Keplerian radii of $2 - 10 \times 10^9$ cm, respectively.

Accepted by: ApJ Letters
For preprints, contact moon@astrosun.tn.cornell.edu
Also available from the URL http://xxx.lanl.gov/abs/astro-ph/0101393

The Metal-rich Globular Cluster NGC6553: Observations with WFPC2, STIS, and NICMOS

Sylvie F. Beaulieu$^1$, Gerard Gilmore$^1$, Rebecca A.W. Elson$^{12}$, Rachel A. Johnson$^1$, Basilio Santiago$^3$, Steinn Sigurdsson$^4$, and Nial Tanvir$^5$

1 Institute of Astronomy, Madingley Road, Cambridge CB3 0HA, UK
2 deceased May 1999
3 Instituto de Física, Universidade Federal Rio Grande do Sul, 91510-970 Porto Alegre, RS Brasil
4 Department of Astronomy & Astrophysics, Pennsylvania State University, University Park, PA 16802, USA
5 Department of Physical Science, University of Hertfordshire, College Lane, Hatfield, AL10 9AB, UK

We present a HST study of the metal-rich globular cluster NGC6553 using WFPC2, NICMOS and STIS. Our primary motivation is to calibrate the STIS broad-band LP magnitude against $V_{555}$ and $I_{814}$ magnitudes for stars of known metallicity and absolute (visual) magnitude, for application to our study of LMC globular clusters. NGC6553 has been shown in earlier studies to have a very unusual colour-magnitude diagram, so we also use our data to investigate the reddening, distance, luminosity function and structure of this cluster. We deduce a higher metallicity and smaller distance modulus than did some previous studies, but emphasise that very large patchy extinction on small angular scales prohibits accurate determination of the parameters of this cluster. The horizontal branch of NGC6553 in $(V, V - I)$ is tilted at an angle close to that of the reddening vector. We show that extinction does not, however, explain the tilt, which is presumably a metallicity effect. The colour-magnitude diagram shows an apparent second turnoff some 1.5 magnitudes fainter than that of the cluster. We show that this is most likely the background Galactic bulge: however, in that case, the colour-magnitude diagram of NGC6553 is not a good match to that of the field bulge population. The cluster is probably more metal-rich than is the mean field bulge star.

Accepted by: AJ
For preprints, contact beaulieu@uvastro.phys.uvic.ca
Meeting Announcement

The Evolution of Galaxies. II. Basic Building Blocks

Ile de la Réunion, France, Oct. 16-21 2001

The evolution of galaxies has become an observational fact mainly after recent sky surveys (e.g. the HST deep field survey, the Canada-France redshift survey, or ISO deep surveys), which have shown that the properties of distant galaxies, formed early in the life of the Universe, differ from those of nearby ones. New observational windows at X-ray, ultraviolet, infrared and millimetric wavelengths (ROSAT, IUE, IRAS, ISO, IRAM) have revealed that galaxies contain a wealth of components (very hot gas, atomic hydrogen, molecules, dust, dark matter).

However, theoretical modeling has not progressed as fast as the census of the content of galaxies. So far, most models are very empirical or semi-empirical. A real understanding of galaxy evolution requires a proper physical description of the galaxy components as well as of the coupling and feedback between them: stars and gas, cold and hot phases of the interstellar medium, large scale and small scale phenomena.

A significant advance is expected in the near future mostly due to the conjunction of two circumstances. On the one hand, the exploration of the most distant Universe will be possible with the new facilities from ground and space (e.g. VLT, FIRST, XMM, etc.). On the other hand, the rapidly developing computing facilities will permit, for the first time, to provide self-consistent models of galaxy evolution. During the next decade, we can expect a breakthrough in galaxy modeling, in which all the relevant large and small scale processes will be taken into account in a coherent way. It will be possible to test this new generation of models against strong observational constraints.

We have started a cycle of three Euroconferences on the evolution of galaxies. The first conference, devoted to the observational clues, took place in May 2000 in Grenada (Spain). The second will take place in October 2001 in the Island of La Reunion (France) in the Indian Ocean and will address the interplay between the different components of a galaxy: interstellar matter, star formation, stellar evolution and death, role of dynamics and environment. The last one will take place in July 2002 in Kiel (Germany) and will address the detailed modeling of galaxy evolution.

Specialists in various fields of Astronomy, observers and theoreticians are expected to participate.

Contact
email: eurogal@cea.fr
web: http://webast.ast.obs-mip.fr/eurogal2/

Important Dates
January 15, 2001 - April 2, 2001 Pre-registration
April 2, 2001 Dead line for final abstract submission
May 2, 2001 Final list of participants and second announcement
October 16-21 2001 Conference