THE MAGELLANIC CLOUDS NEWSLETTER
An electronic exchange on Magellanic Clouds research

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News

Catalog of Extended Objects in the Magellanic Clouds available on-line

We constructed a unified catalog of clusters, associations and emission nebulae in the Magellanic Clouds using the ESO/SERC R and J Sky Survey Atlases. This catalog contains a total population of 7847 extended objects, many of them not reported in previous catalogs. The census and spatial distribution analyses of these objects are presented in Paper I (Bica, E. & Schmitt, H.R., 1995, ApJS, 101,41) and Paper II (Bica, E., Schmitt, H.R., Dutra, C.M., & Oliveira, H. 1998, AJ, in press (December issue)).

The catalogs with J2000 positions can be downloaded from
http://www.if.ufrgs.br/~dutra/catpage.html.
We plan to keep updated versions of the catalogs with new information from the literature.

E. Bica, H.R. Schmitt, C.M. Dutra, H. Oliveira
Abstracts of Refereed Papers

Detection of Cold Atomic Clouds in the Magellanic Bridge

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We report a direct detection of cold atomic hydrogen in the Magellanic Bridge using 21-cm absorption spectroscopy toward the radio source B0312-770. With a maximum absorption optical depth of $\tau = 0.10$ and a maximum 21-cm emission brightness temperature of 1.4 K ($N_{HI} = 1.2 \times 10^{20} \text{ cm}^{-2}$), this line of sight yields a spin temperature, $T_s$, between 20 K and 40 K. H I 21-cm absorption and emission spectroscopy toward 7 other low H I column density sightlines on the periphery of the LMC and SMC reveal absorption toward one additional background radio source behind the SMC with $\tau = 0.03$. The data have typical sensitivities of $\sigma_T = 0.005$ to 0.070 in absorption and $\sigma_{T_B} = 0.03$ K in emission. These data demonstrate the presence of a cold atomic phase which is probably accompanied by molecular condensations in the tenuous interstellar medium of the Bridge region. Young OB stars observed in the Magellanic Bridge could form \textit{in situ} from these cold condensations rather than migrate from regions of active star formation in the main body of the SMC. The existence of cold condensations and star formation in the Magellanic Bridge might be understood as a small scale version of the mechanism that produces star formation in the tidal tails of interacting galaxies.

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Also available from the URL http://xxx.lanl.gov/abs/astro-ph/9810245

A revised and extended catalog of Magellanic System clusters, associations and emission nebulae. II. the LMC

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A survey of extended objects in the Large Magellanic Cloud was carried out on the ESO/SERC R and J Sky Survey Atlases, checking entries in previous catalogs and searching for new objects. The census provided 6659 objects including star clusters, emission-free associations and objects related to emission nebulae. Each of these classes contains 3 subclasses with intermediate properties, which are used to infer total populations. The survey includes cross-identifications among catalogs and we present 3246 new objects. We provide accurate positions, classification, homogeneous measurements of sizes and position angles, as well as information on cluster pairs and hierarchical relation for superimposed objects. This unification and enlargement of catalogs is important for future searches of fainter and smaller new objects. We discuss the angular and size distributions of the objects of the different classes. The angular distributions show two off-centered systems with different inclinations, suggesting that the LMC disk is warped. The present catalog together with its previous counterpart
for the SMC and the inter-Cloud region provide a total population of 7847 extended objects in the Magellanic System. The angular distribution of the ensemble reveals important clues on the interaction between the LMC and SMC.

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or by anonymous ftp at if1.if.ufrgs.br

Spectroscopy of Be stars in the Small Magellanic Cloud cluster NGC 330

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The presence of an anomalously large population of Be stars in the young cluster NGC 330 in the SMC has been noted by Grebel et al. (1992) and most recently Keller et al. (1998). We present results from follow-up medium resolution spectra of the bright Be stars identified in Keller et al. (1998) and in the spectroscopic study of Mazzali et al. (1996). We find that the study of Mazzali et al. has overestimated the number of Be stars within NGC 330. Many of the bright B type stars identified by Mazzali et al. as Be stars show no signs of emission after correction for the diffuse HII emission pervading the cluster field.

In the study of Mazzali et al. (1996) evidence is presented suggesting that all Be stars in NGC 330 have a common inclination of their rotation axes to the line of sight. For our sample of Be stars we present the emission equivalent widths and observed rotational velocities. An examination of these quantities shows that there is no evidence of a preferential alignment of the rotational axes, rather we are observing a population with random rotational axis alignment and disk size.

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Also available from the URL http://msoww.anu.edu.au/~stefan/work.html

ROSAT HRI Detection of the 16 ms Pulsar PSR J0537-6910 Inside SNR N157B

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Based on a deep ROSAT HRI observation, we have detected a pulsed signal in the 0.1-2 keV band from PSR J0537-6910 — the recently discovered pulsar associated with the supernova remnant N157B in the Large Magellanic Cloud. The measured pulse period 0.01611548182 s ± 0.02(ns), Epoch MJD 50540.5, gives a revised linear spin-down rate of $5.1271 \times 10^{-14}$ s$^{-1}$, slightly greater than the previously derived value. The narrow pulse shape (FWHM ~ 10% duty cycle) in the ROSAT band resembles those seen in both RXTE and ASCA data (≥ 2 keV), but there is also marginal evidence
for an interpulse. This ROSAT detection enables us to locate the pulsar at R.A., Dec (J2000) = 5h37m47.2s, −69°10′23″. With its uncertainty ∼ 3″, this position coincides with the centroid of a compact X-ray source. But the pulsed emission accounts for only ∼ 10% of the source luminosity ∼ 2 × 10³⁶ergs⁻¹ in the 0.1-2 keV band. These results support our previous suggestions: (1) The pulsar is moving at a high velocity (∼ 10³kms⁻¹); (2) A bow shock, formed around the pulsar, is responsible for most of the X-ray emission from the source; (3) A collimated outflow from the bow shock region powers a pulsar wind nebula that accounts for an elongated non-thermal radio and X-ray feature to the northwest of the pulsar.

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Also available from the URL http://www.astro.nwu.edu/astro/wqd/index.html

Abstracts of Non-Refereed Papers

Star Clusters in the Magellanic Clouds

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Recent results for the old and intermediate-age star clusters of the Magellanic Clouds are reviewed. Highlights include new evidence that the LMC old clusters are as old the Galaxy’s halo globular clusters and the persistence of the LMC cluster “Age Gap” despite field star evidence for significant star formation during the cluster age gap epoch. For the SMC new data confirm the lack of significant change in cluster abundances with age prior to ∼4 Gyr ago.

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Results from *HST* Observations of Six LMC Globular Cluster Fields

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We present deep *HST* color-magnitude diagrams of fields centered on the six old LMC globular clusters NGC 1754, NGC 1835, NGC 1898, NGC 1916, NGC 2005, and NGC 2019. Separate cluster and field star CMDs are shown. The time of formation of the LMC is studied from an analysis of the cluster CMDs. Based on a comparison of the CMDs with sequences of the Milky Way clusters M3, M5, and M55, we suggest that the LMC formed its first stars at the same time as the Milky Way to within 1 Gyr. We find additional evidence that these LMC globular clusters are as old as the oldest Milky Way clusters through a comparison of our data with the horizontal branch evolutionary models of Lee, Demarque, & Zinn (1994).

The evolution of the LMC following its formation is studied through an analysis of the field star CMDs. Through an automated comparison with stellar evolution models, we extract the star formation histories implied by the CMDs. Our best-fit star formation histories imply that the LMC has been actively forming stars over the last 4 Gyr, in agreement with previous field star studies. The four fields that lie in the Bar also contain significant numbers of stars with ages of 4–8 Gyr in the best-fit cases. The most notable disagreement between the best-fit models and observed CMDs is in the color of the red giant branch.

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Red giant stars in Magellanic Cloud clusters: constraining population synthesis models

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We have computed new sets of stellar evolutionary tracks, and developed a population synthesis code aimed mainly at the interpretation of colour-magnitude diagrams. Magellanic Cloud clusters have been largely used for the test and calibration of the stellar tracks.

*For preprints, contact* leog@mpa-garching.mpg.de  
*Also available from the URL* [http://www.mpa-garching.mpg.de/~leog/articles.html](http://www.mpa-garching.mpg.de/~leog/articles.html)
The MACHO Project LMC Variable Star Inventory: Classical Cepheids, AGB Variables, and the 9 Million Star Color-Magnitude Diagram

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We measure the ratio of $\sim 5M_\odot$ blue and red LMC supergiants (representative of classical Cepheids) using the MACHO Project’s 9 million star color-magnitude diagram (9MCMD) of the LMC bar. We find $b/r = 0.39$, which favors the $z=0.008, 5M_\odot$ theoretical model of Schaefer et al. (1993) over that of Fagotto et al. (1994). Next, we examine the low mass (old) and low metallicity LMC field population (Pop. II). Features in the 9MCMD and properties of LMC field RRab variables are consistent with a mean iron abundance of $[\text{Fe/H}] \approx -1.5$ dex for this population. Newly discovered post-HB/early-AGB Pop. II variables are identified in order to delineate the instability strip (IS). Good agreement with the theoretical IS of Bono et al. (1997) is found. We then compare the field RRab with newly identified RRab variables in the LMC clusters NGC 1898 and NGC 1835. We find the mean colors of these cluster RRab lie near the red and blue edges of the IS, respectively, which is similar to their respective (overall) red and blue HB morphologies. Since the field RRab lie on the red side of the IS, we infer the LMC field Pop. II is likely to have a red HB morphology.


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Also available from the URL http://xxx.1an1.gov/abs/astro-ph/9810221
Mass loss and AGB evolution in Galactic satellites

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The effect of metallicity on the mass loss on the Asymptotic Giant Branch is reviewed. Observations have mainly been limited to the Magellanic Clouds but are observationally feasible throughout the Local Group. The expansion velocity of the circumstellar shell is predicted by models to depend strongly on Z. The few observations available show that this effect may be present although possibly not as large as predicted: expansion velocities in the LMC appear to be between 15 and 40 per cent lower than in the Galaxy. The peak mass-loss rates reached on the AGB do not appear to depend on metallicity.

The Mira period-luminosity relation (using K-band magnitudes) shows no evidence for a Z-dependence, comparing Hipparcos Miras with Miras in Globular Clusters and in the LMC. If this is confirmed, Miras would yield a powerful potential distance indicator. Assuming no Z-dependence, I derive a distance modulus to the LMC of $m - M = 18.63 \pm 0.09$ as well as a bright calibration for the Horizontal Branch in globular clusters.

The predicted initial-final mass relation for AGB stars at low-Z is shown to give rise to higher mass remnants. This would result in an increased supernova rate in young, low-Z populations, such as found in the early Universe.


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Also available from the URL: http://xxx.lanl.gov/abs/astro-ph/9810278

MACHO observations of LMC red giants:
Mira and semi-regular pulsators,
and contact and semi-detached binaries

P.R. Wood\footnote{Mount Stromlo and Siding Spring Observatories, Australian National University.} and the MACHO Collaboration

The MACHO data base has been used to examine light curves of all red giant stars brighter than $M_{bol} \sim -2$ in a 0.5deg\times0.5deg area of the LMC bar. Periods, often multiple, have been searched for in all stars found to be variable. Five distinct period-luminosity sequences have been found on the low mass ($M \lessapprox 2.25 M_\odot$) giant branch. Comparison of observed periods, luminosities and period ratios with theoretical models identifies Miras unambiguously as radial fundamental mode pulsators, while semi-regular variables can be pulsating in the 1st, 2nd or 3rd overtone, or even the fundamental. All these variables lie on just 3 of the 5 distinct sequences, and they all appear to be on the AGB.

The fourth sequence contains red giants on the first giant branch (FGB) or at the red end of the core-helium burning loops of intermediate mass stars ($M \succeq 2.25 M_\odot$). The light curves of these stars strongly suggest that they are contact binaries, and they make up \sim 0.5\% of stars within 1 mag. of the FGB tip. Stars on the fifth sequence show semi-regular, eclipse-like light curves. The light curves and periods of these stars suggest that they are in semi-detached binaries, transferring mass to an invisible companion via a stellar wind or Roche lobe overflow. They make up \sim 25\% of AGB stars.
the existence of these red giant contact and semi-detached binaries is confirmed, then extant theories of binary star evolution will require substantial modification.

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RXTE Observations of LMC X-1 and LMC X-3

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Of all known persistent stellar-mass black hole candidates, only LMC X-1 and LMC X-3 consistently show spectra that are dominated by a soft, thermal component. We present results from long (170 ksec) Rossi X-ray Timing Explorer (RXTE) observations of LMC X-1 and LMC X-3 made in 1996 December. The spectra can be described by a multicolor disk blackbody plus an additional high-energy power-law. Even though the spectra are very soft ($\Gamma \sim 2.5$), RXTE detected a significant signal from LMC X-3 up to energies of 50 keV, the hardest energy at which the object was ever detected.

Focusing on LMC X-3, we present results from the first year of an ongoing monitoring campaign with RXTE which started in 1997 January. We show that the appearance of the object changes considerably over its $\sim 200$ d long cycle. This variability can either be explained by periodic changes in the mass transfer rate or by a precessing accretion disk analogous to Her X-1.

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The Case for a Next Generation Microlensing Survey

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Microlensing surveys search for the transient brightening of a background star that is the signature of gravitational lensing by a foreground compact object. This technique is an elegant way to search for astrophysical candidates that might comprise the dark matter halo of the Milky Way. While the current projects have successfully detected the phenomenon of microlensing and have reported many important results, the relatively large event rate reported towards the LMC remains a puzzle. The first step in resolving this mystery is determining the location of the excess lensing population. This will require a microlensing survey with an order of magnitude increase in sensitivity over current projects.
I summarize the present status of microlensing surveys, and present (and advocate!) a next-generation project that should be capable of unambiguously determining whether the dark halo of the Galaxy is indeed made up of MACHOs, or whether the observed events are due to previously unappreciated ordinary stellar populations.


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