Editorial

Dear Colleagues,

It is our pleasure to present the 87th issue of the Magellanic Clouds Newsletter.

Research on and in the Magellanic Clouds remains vibrant. The abstracts of 18 refereed journal papers were posted, addressing topics that range from star formation and supernovae, their progenitors and remnants, to the molecular ISM. The recent SN 1987A birthday party has resulted in many interesting papers on this "pride of the LMC", with probably more to come in the next issue of the newsletter. Note also the new calibration of the distance to the LMC.

You are warmly invited to pre-register at http://www.astro.keele.ac.uk/iaus256, so as to be sure not to miss out on the first and future announcements for IAU Symposium 256 on The Magellanic System (Keele, 2008).

The next issue will be distributed on the 1st of August; the deadline for contributions is the 31st of July.

Editorially Yours,
Jacco van Loon and Snežana Stanimirović
Star-forming Regions in the Small Magellanic Cloud Multi-wavelength Properties of Stellar Complexes

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We trace the star formation regions in the SMC and study their properties. The size and spatial distribution of these regions is found to support the hierarchical scenario of star formation, whereas, the evaluation of their intensity, contributes to the understanding of the various stages of star formation. Their connection to the LMC-SMC close encounter, about (0.9 - 2) x 10^8 years ago, is investigated as well. The SMC, being almost edge-on, does not easily reveal these areas, as is the case with the LMC. However, a study through multi-wavelength images such as optical, IR and radio has been proved very useful. A selection of areas, with enhanced 60 and 100 µm infrared flux and emission in all IRAS bands, identifies the star forming regions. All of the identified regions are dominated by early-type stars and considering their overall size (increasing order) a total of 24 aggregates, 23 complexes, and 3 super-complexes were found. We present their coordinates, dimensions, and IR fluxes. Moreover, we correlate their positions with known associations, SNRs, and HII regions and discuss their activity.

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The Detection of Far Ultraviolet Line Emission from Balmer-Dominated Supernova Remnants in the Large Magellanic Cloud

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We present the first far ultraviolet (FUV) spectra of the four known Balmer-dominated supernova remnants (SNRs) in the Large Magellanic Cloud, acquired with the Far Ultraviolet Spectroscopic Explorer. The remnants DEM L 71 (0505–67.9), 0509–67.5, 0519–69.0 and 0548–70.4 are all in the non-radiative stages of evolution and exhibit expansion speeds ranging from ~ 500 km s^{-1} to ~ 5000 km s^{-1}. We have detected broad emission lines of Ly $\beta$, Ly $\gamma$, C III and O VI in DEM L 71 (V(FWHM) ~ 1000 km s^{-1}) and have detected broad Ly $\beta$ and O VI emission in 0519–69.0, (V(FWHM) ~ 3000 km s^{-1}). In addition, broad Ly $\beta$ emission (V(FWHM) ~ 3700 km s^{-1}) has been observed in 0509–67.5, the first detection of broad line emission from this SNR. No emission was detected in our FUSE spectrum of 0548–70.4, allowing us to place only upper limits on the FUV line fluxes. The spectra of these SNRs are unaffected by postshock cooling, and provide valuable probes of collisionless heating efficiency in high Mach number shocks. We have used the Ly $\beta$ / O VI flux ratio and relative widths of the broad Ly $\beta$ and O VI lines to estimate the degree of electron-proton and proton-oxygen ion equilibration in DEM L 71, 0509–67.5, and 0519–69.0.

Although our equilibration estimates are subject to considerable uncertainty due to the faintness of the FUV lines and contributions from bulk Doppler broadening, our results are consistent with a declining efficiency of electron- proton
and proton-oxygen ion equilibration with increasing shock speed. From our shock velocity estimates we obtain ages of 295-585 years for 0509 \( \pm \) 67.5 and 520-900 years for 0519 \( \pm \) 69.0, respectively, in good agreement with the ages obtained from SN light echo studies.

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Multi-frequency Study of the LMC Supernova Remnant (SNR) B0513–692 and New SNR Candidate J051327–6911

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We present a new multi-wavelength study of supernova remnant (SNR) B0513–692 in the Large Magellanic Cloud (LMC). The remnant also has a strong, superposed, essentially unresolved, but unrelated radio source at its north-western edge, J051324–691049. This is identified as a likely compact H\textsc{ii} region based on related optical imaging and spectroscopy. We use the Australia Telescope Compact Array (ATCA) at 4790 and 8640 MHz (\( \lambda \approx 6 \) cm and \( \lambda \approx 3.5 \) cm) to determine the large scale morphology, spectral index and polarization characteristics of B0513–692 for the first time. We detect a strongly polarized region (49\%) in the remnant’s southern edge (\( \lambda \approx 6 \) cm). Interestingly we also detect a small (\( \approx 40 \) arcsec) moderately bright, but distinct optical, circular shell in our H\alpha imagery which is adjacent to the compact H\textsc{ii} region and just within the borders of the NE edge of B0513–692. We suggest this is a separate new SNR candidate based on its apparently distinct character in terms of optical morphology in 3 imaged emission lines and indicative SNR optical spectroscopy (including enhanced optical S\textsc{ii} emission relative to H\alpha).

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Eclipsing binaries in the MACHO database: New periods and classifications for 3031 systems in the Large Magellanic Cloud

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Eclipsing binaries offer a unique opportunity to determine fundamental physical parameters of stars using the constraints on the geometry of the systems. Here we present a reanalysis of publicly available two-color observations of about 6800 stars in the Large Magellanic Cloud, obtained by the MACHO project between 1992 and 2000 and classified as eclipsing variable stars. Of these, less than half are genuine eclipsing binaries. We determined new periods and classified the stars, 3031 in total, using the Fourier parameters of the phased light curves. The period distribution is clearly bimodal, reflecting the separate groups of more massive blue main sequence objects and low mass red giants. The latter resemble contact binaries and obey a period-luminosity relation. Using evolutionary models, we identified foreground stars. The presented database has been cleaned of artifacts and misclassified variables, thus allowing searches for apsidal motion, tertiary components, pulsating stars in binary systems and secular variations with time-scales of several years.

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High resolution spectroscopy of the line emission from the inner circumstellar ring of SN 1987A and its hot spots

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We discuss high resolution VLT/UVES observations (FWHM $\sim$ 6 km s$^{-1}$) from October 2002 (day $\sim$ 5700 past explosion) of the shock interaction of SN 1987A and its circumstellar ring. A nebular analysis of the narrow lines from the unshocked gas indicates gas densities of $(\sim 1.5 - 5.0) \times 10^{3}$ cm$^{-3}$ and temperatures of $\sim 6.5 \times 10^{3}$ – $2.4 \times 10^{4}$ K. This is consistent with the thermal widths of the lines. From the shocked component we observe a large range of ionization stages from neutral lines to [Fe xiv]. From a nebular analysis we find that the density in the low ionization region is $4 \times 10^{6} - 10^{7}$ cm$^{-3}$. There is a clear difference in the high velocity extension of the low ionization lines and that of lines from [Fe x-xiv], with the latter extending up to $\sim$ 390 km s$^{-1}$ in the blue wing for [Fe xiv], while the low ionization lines extend to typically $\sim$ 260 km s$^{-1}$. For H$\alpha$ a faint extension up to $\sim$ 450 km s$^{-1}$ can be seen probably arising from a small fraction of shocked high density clumps. We discuss these observations in the context of radiative shock models, which are qualitatively consistent with the observations. A fraction of the high ionization lines may originate in gas which has yet not had time to cool down, explaining the difference in width between the low and high ionization lines. The maximum shock velocities seen in the optical lines are $\sim$ 510 km s$^{-1}$. We expect the maximum width of especially the low ionization lines to increase with time.

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A Preliminary Chandra X-ray Spectroscopy of the Supernova Remnant N132D

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We present the preliminary results of a Chandra X-ray study of N132D, a young shell-like supernova remnant (SNR) in the Large Magellanic Cloud. The equivalent width maps of emissions from O, Ne, Mg, Si, and S are provided. Spatially resolved spectral analysis for the small-scale regions were tentatively performed. The X-ray spectra of the interior can be described with a single-thermal model. The faint interior regions have lower density and higher temperature (above 1keV) than those of bright interior regions. The X-ray spectra along the shell can be phenomenally fitted with either a double-vpshock model or a vpshock + powerlaw model. If the non-thermal component is true, N132D would be listed as another X-ray synchrotron SNR.

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Old Main-Sequence Turnoff Photometry in the Small Magellanic Cloud. I. Constraints on the Star Formation History in Different Fields

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We present ground-based B and R-band color-magnitude diagrams (CMDs), reaching the oldest main-sequence turnoffs with good photometric accuracy for twelve fields in the Small Magellanic Cloud (SMC). Our fields, located between
\( \sim 1 \) and \( \sim 4 \) degrees from the center of the galaxy, are situated in different parts of the SMC such as the "Wing" area, and towards the West and South. In this paper we perform a first analysis of the stellar content in our SMC fields through comparison with theoretical isochrones and color functions (CFs). We find that the underlying spheroidally distributed population is composed of both intermediate-age and old stars and that its age composition does not show strong galacto-centric gradients. The three fields situated toward the east, in the Wing region, show very active current star formation. However, only in the eastern field closest to the center do we find an enhancement of recent star formation with respect to a constant SFR(t). The fields corresponding to the western side of the SMC present a much less populated young MS, and the CF analysis indicates that the SFR(t) greatly diminished around 2 Gyr ago in these parts. Field smc0057, the closest to the center of the galaxy and located in the southern part, shows recent star formation, while the rest of the southern fields present few bright MS stars. The structure of the red clump in all the CMDs is consistent with the large amount of intermediate-age stars inferred from the CMDs and color functions. None of the SMC fields presented here are dominated by old stellar populations, a fact that is in agreement with the lack of a conspicuous horizontal branch in all these SMC CMDs. This could indicate that a disk population is ruling over a possible old halo in all the observed fields.

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The VLT-FLAMES survey of massive stars: Wind properties and evolution of hot massive stars in the LMC

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We have studied the optical spectra of a sample of 28 O- and early B-type stars in the Large Magellanic Cloud, 22 of which are associated with the young star forming region N11. Our observations sample the central associations of LH9 and LH10, and the surrounding regions. Stellar parameters are determined using an automated fitting method (Mokiem et al. 2005), which combines the stellar atmosphere code fastwind (Puls et al. 2005) with the genetic algorithm based optimisation routine pikaia (Charbonneau 1995). We derive an age of \( 7.0 \pm 1.0 \) and \( 3.0 \pm 1.0 \) Myr for LH9 and LH10, respectively. The age difference and relative distance of the associations are consistent with a sequential star formation scenario in which stellar activity in LH9 triggered the formation of LH10. Our sample contains four stars of spectral type O2. From helium and hydrogen line fitting we find the hottest three of these stars to be \( \sim 49 - 54 \) kK (compared to \( \sim 45 - 46 \) kK for O3 stars). Detailed determination of the helium mass fraction reveals that the masses of helium enriched dwarfs and giants derived in our spectroscopic analysis are systematically lower than those implied by non-rotating evolutionary tracks. We interpret this as evidence for efficient rotationally enhanced mixing leading to the surfacing of primary helium and to an increase of the stellar luminosity. This result is consistent with findings for SMC stars by Mokiem et al. (2006). For bright giants and supergiants no such mass discrepancy is found; these stars therefore appear to follow tracks of modestly or non-rotating objects. The set of programme stars was sufficiently large to establish the mass loss rates of OB stars in this \( Z \sim 1/2 \ Z_{\odot} \) environment sufficiently accurate to allow for a \textit{quantitative} comparison with similar objects in the Galaxy and the SMC. The mass loss properties are found to be intermediate to massive stars in the Galaxy and SMC. Comparing the derived modified wind momenta \( D_{\text{mom}} \) as a function of luminosity with predictions for LMC metallicities by Vink et al. (2001) yields good agreement in the entire luminosity range that was investigated, i.e. \( 5.0 < \log L/L_{\odot} < 6.1 \).

Extinction in the Large Magellanic Cloud

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We present an extinction map of the Large Magellanic Cloud (LMC), using 204,502 stars from the Two Micron All Sky Survey point source catalog. We first use the \text{nice} method to determine the reddening distribution, \( E(H-K) \) and \( E(J-H) \), which we compare to the \( \text{H} \) \( \text{i} \) distribution to find a near-infrared reddening law of \( E(J-H)/E(H-K) = 1.20 \pm 0.04 \). A visual extinction map (6\(^\circ\) × 6\(^\circ\)) of the LMC is created using the \text{nicer} method; at 4\('\) resolution, a mean value of \( A_V = 0.38 \) mag is found. We derive the LMC CO-to-\( \text{H}_2 \) conversion factor, \( X \), independent of assumptions about the virialization of giant molecular clouds, by comparing the \text{nicer} extinction map with NANTEN CO observations. In regions where \( A_V > 1 \) mag and CO emission is > 2 K km s\(^{-1}\), we measure \( X = 9.3 \pm 0.4 \times 10^{20} \) (cm\(^2\) K km s\(^{-1}\))\(^{-1}\). In the same regions, the LMC contains a total molecular mass of \( \sim 4.5 \times 10^7 \) M\(_\odot\).

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AKARI Detection of the Infrared-Bright Supernova Remnant B0104−72.3 in the Small Magellanic Cloud

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We present a serendipitous detection of the infrared-bright supernova remnant (SNR) B0104−72.3 in the Small Magellanic Cloud by the Infrared Camera (IRC) onboard AKARI. An elongated, partially complete shell is detected in all four observed IRC bands covering 2.6-15 \( \mu \)m. The infrared shell surrounds radio, optical, and X-ray emission associated with the SNR and is probably a radiative SNR shell. This is the first detection of a SNR shell in this near/mid-infrared waveband in the Small Magellanic Cloud. The IRC color indicates that the infrared emission might be from shocked \( \text{H}_2 \) molecules with some possible contributions from ionic lines. We conclude that B0104−72.3 is a middle-aged SNR interacting with molecular clouds, similar to the Galactic SNR IC 443. Our results highlight the potential of AKARI IRC observations in studying SNRs, especially for diagnosing SNR shocks.

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Constraining GRB progenitor models by probing Wolf-Rayet wind geometries in the Large Magellanic Cloud

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The favoured progenitors of long-duration gamma-ray bursts (GRBs) are rapidly rotating Wolf-Rayet (WR) stars. However, most Galactic WR stars are slow rotators, as stellar winds are thought to remove angular momentum. This poses a serious challenge to the collapsar model. Recent observations indicate that GRBs occur predominately in low metallicity (Z) environments, which may resolve the problem: lower Z leads to less mass loss, which may inhibit angular momentum removal, allowing WR stars to remain rotating rapidly until collapse. We wish to determine whether low Z WR stars rotate on average more rapidly than Galactic WR stars, and we perform a Very Large Telescope (VLT) linear spectropolarimetry survey of WR stars in the low Z environment of the Large Magellanic Cloud (LMC) and compare our results with the Galactic sample of Harries et al. (1998). We find that only 2 out of 13 (i.e. 15%) of LMC WR stars show line polarization effects, compared to a similarly low fraction of \( \sim 15 - 20\% \) for Galactic WR
stars. The low incidence of line polarization effects in LMC WR stars suggests that the threshold metallicity where significant differences in WR rotational properties occur is below that of the LMC ($Z \approx 0.5 Z_\odot$), possibly constraining GRB progenitor channels to this upper metallicity.

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The star-formation region NGC 346 in the Small Magellanic Cloud with Hubble Space Telescope ACS observations. II. Photometric study of the intermediate-age star cluster BS 90

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We present the results of our investigation of the intermediate-age star cluster BS 90, located in the vicinity of the H II region N66 in the SMC, observed with HST/ACS. The high-resolution data provide a unique opportunity for a very detailed photometric study performed on one of the rare intermediate-age rich SMC clusters. The complete set of observations is centered on the association NGC 346 and contains almost 100,000 stars down to $V \approx 28$ mag.

In this study we focus on the northern part of the region, which covers almost the whole stellar content of BS 90. We construct its stellar surface density profile and derive structural parameters. Isochrone fits on the CMD of the cluster results in an age of about 4.5 Gyr. The luminosity function is constructed and the present-day mass function of BS 90 has been obtained using the mass-luminosity relation, derived from the isochrone models. We found a slope between $-1.30$ and $-0.95$, comparable or somewhat shallower than a typical Salpeter IMF. Examination of the radial dependence of the mass function shows a steeper slope at larger radial distances, indicating mass segregation in the cluster. The derived half-mass relaxation time of 0.95 Gyr suggests that the cluster is mass segregated due to its dynamical evolution. From the isochrone model fits we derive a metallicity for BS 90 of $[\text{Fe/H}] = -0.72$, which adds an important point to the age-metallicity relation of the SMC. We discuss our findings on this relation in comparison to other SMC clusters.

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Millimeter dust continuum emission unveiling the true mass of giant molecular cloud in the Small Magellanic Cloud

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CO observations have been so far the best way to trace molecular gas in external galaxies, but in low metallicity environments the gas mass deduced could be largely underestimated due to enhanced photodissociation of the CO molecule. Large envelopes of H$_2$ could therefore be missed by CO observations. At present, the kinematic information of CO data cubes are used to estimate virial masses and trace the total mass of the molecular clouds. Millimeter dust
emission can also be used as a dense gas tracer and could unveil H$_2$ envelopes lacking CO. These different tracers must be compared in different environments. This study compares virial masses to masses deduced from millimeter emission, in two GMC samples: the local molecular clouds in our Galaxy (10$^4$ – 10$^5$ M$_\odot$), and their equivalents in the Small Magellanic Cloud (SMC), one of the nearest low metallicity dwarf galaxy. In our Galaxy, mass estimates deduced from millimeter (FIRAS) emission are consistent with masses deduced from gamma ray analysis (Grenier et al. 2005) and therefore trace the total mass of the clouds. Virial masses are systematically larger (twice on average) than mass estimates from millimeter dust emission. This difference decreases toward high masses and has already been reported in previous studies. This is not the case for SMC giant molecular clouds: molecular cloud masses deduced from SIMBA millimeter observations are systematically higher (twice on average for conservative values of the dust to gas ratio and dust emissivity) than the virial masses from SEST CO observations. The observed excess can not be accounted for by any plausible change of dust properties. Taking a general form for the virial theorem, we show that a magnetic field strength of 15 $\mu$Gauss in SMC clouds could provide additional support to the clouds and explain the difference observed. Masses of SMC molecular clouds have so far been underestimated. Magnetic pressure may contribute significantly to their support.

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The effect of stellar-mass black holes on the structural evolution of massive star clusters

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We present the results of realistic $N$-body modelling of massive star clusters in the Magellanic Clouds, aimed at investigating a dynamical origin for the radius-age trend observed in these systems. We find that stellar-mass black holes, formed in the supernova explosions of the most massive cluster stars, can constitute a dynamically important population. If a significant population is retained (here we assume complete retention), these objects rapidly form a dense core where interactions are common, resulting in the scattering of black holes into the cluster halo, and the ejection of black holes from the cluster. These two processes heat the stellar component, resulting in prolonged core expansion of a magnitude matching the observations. Significant core evolution is also observed in Magellanic Cloud clusters at early times. We find that this does not result from the action of black holes, but can be reproduced by the effects of mass-loss due to rapid stellar evolution in a primordially mass segregated cluster.

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A double main sequence turn-off in the rich star cluster NGC 1846 in the Large Magellanic Cloud

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We report on HST/ACS photometry of the rich intermediate-age star cluster NGC 1846 in the Large Magellanic Cloud, which clearly reveals the presence of a double main sequence turn-off in this object. Despite this, the main sequence, sub-giant branch, and red giant branch are all narrow and well-defined, and the red clump is compact. We
examine the spatial distribution of turn-off stars and demonstrate that all belong to NGC 1846 rather than to any field star population. In addition, the spatial distributions of the two sets of turn-off stars may exhibit different central concentrations and some asymmetries. By fitting isochrones, we show that the properties of the colour-magnitude diagram can be explained if there are two stellar populations of equivalent metal abundance in NGC 1846, differing in age by $\approx 300$ Myr. The absolute ages of the two populations are $\sim 1.9$ and $\sim 2.2$ Gyr, although there may be a systematic error of up to $\pm 0.4$ Gyr in these values. The metal abundance inferred from isochrone fitting is $[\text{M}/\text{H}] \approx -0.40$, consistent with spectroscopic measurements of $[\text{Fe}/\text{H}]$. We propose that the observed properties of NGC 1846 can be explained if this object originated via the tidal capture of two star clusters formed separately in a star cluster group in a single giant molecular cloud. This scenario accounts naturally for the age difference and uniform metallicity of the two member populations, as well as the differences in their spatial distributions.

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Investigations of the Non-Linear LMC Cepheid Period-Luminosity Relation with Testimator and Schwarz Information Criterion Methods

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In this paper, we investigate the linearity versus non-linearity of the Large Magellanic Cloud (LMC) Cepheid period-luminosity (P-L) relation using two statistical approaches not previously applied to this problem: the testimator method and the Schwarz Information Criterion (SIC). The testimator method is extended to multiple stages for the first time, shown to be unbiased and the variance of the estimated slope can be proved to be smaller than the standard slope estimated from linear regression theory. The Schwarz Information Criterion (also known as the Bayesian Information Criterion) is more conservative than the Akaike Information Criterion and tends to choose lower order models. By using simulated data sets, we verify that these statistical techniques can be used to detect intrinsically linear and/or non-linear P-L relations. These methods are then applied to independent LMC Cepheid data sets from the OGLE project and the MACHO project, respectively. Our results imply that there is a change of slope in longer period ranges for all of the data sets. This strongly supports previous results, obtained from independent statistical tests, that the observed LMC P-L relation is non-linear with a break period at/around 10 days.

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CO and CS in the Magellanic Clouds: a $\chi^2$–analysis of multitransitional data based on the MEP radiative transfer model

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To determine the physical properties of molecular gas located in different environments of the SMC – from near the vicinity of hot HII regions to cold, quiescent clouds – via modelling and simulations, and compare with the properties of molecular gas found in similar environments in the LMC. We present observations of the $^{12}$CO (1−0), (2−1), (3−2), $^{13}$CO (1−0), (2−1) and CS (2−1), (3−2) line emission toward six molecular clouds in the SMC: N 66, N 88, Lirs 36, Lirs 49, Hodge 15 and SMC-B1#1. These data, as well as published data on three clouds of the LMC: 30 Dor-10, N 159-W and N 159-S, are analysed to estimate gas kinetic
temperatures, column densities and surface filling factors using a Mean Escape Probability approximation of the radiative transfer equations. The solutions are restricted using the $\chi^2$ approach.

Assuming that the $^{12}$CO/$^{13}$CO abundance ratio is similar in both galaxies, we find that the CO and CS column densities of SMC clouds are a magnitude smaller than those of LMC clouds, mirroring the metallicity differences. Our analysis suggests the existence of a lower limit for the $^{12}$CO/$^{13}$CO isotope ratio of 50 in both galaxies. The surface filling factors of the CO emission in the SMC clouds are a factor of a few smaller than in the LMC and seem to decrease with increasing UV radiation fields, i.e., more vigorous star formation activity. A simple model, which assumes a spherical cloud with uniform physical parameters immersed in the CMB radiation field, provides a reasonably good fit to the observed properties of the (supposedly) quiescent clouds SMC-B1#1 and N159-S. For all other clouds considered, this model gives large values of $\chi^2$, strongly indicating the need of a more complex model. We present some results from 2-component modelling, e.g., for Lirs 36 a mixture of 20 K gas with high optical depth and a less dense gas with temperatures of 100 K reproduces well the main features of the CO data.

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Cepheid Parallaxes and the Hubble Constant

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Revised Hipparcos parallaxes for classical Cepheids are analysed together with 10 HST-based parallaxes (Benedict et al.). In a reddening-free V,I relation we find that the coefficient of logP is the same within the uncertainties in our Galaxy as in the LMC, contrary to some previous suggestions. Cepheids in the inner region of NGC 4258 with near solar metallicities (Macri et al.) confirm this result. We obtain a zero-point for the reddening-free relation and apply it to the Cepheids in galaxies used by Sandage et al. to calibrate the absolute magnitudes of SNIa and to derive the Hubble constant. We revise their result for $H_0$ from 62 to 70 $\pm$ 5 km s$^{-1}$ Mpc$^{-1}$. The Freedman et al. (2001) value is revised from 72 to 76 $\pm$ 8 km s$^{-1}$ Mpc$^{-1}$. These results are insensitive to Cepheid metallicity corrections. The Cepheids in the inner region of NGC 4258 yield a modulus of 29.22 $\pm$ 0.03(int) compared to a maser-based modulus of 29.29 $\pm$ 0.15. Distance moduli for the LMC, uncorrected for any metallicity effects are: 18.52 $\pm$ 0.03 from a reddening-free relation in V,I; 18.47 $\pm$ 0.03 from a period-luminosity relation at K; 18.45 $\pm$ 0.04 from a period-luminosity-colour relation in J,K. Adopting a metallicity correction in V,I from Macri et al. leads to a true LMC modulus of 18.39 $\pm$ 0.05.

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Conference Papers

The SMC Super-Shells as Probes of the Turbulent Dynamics of the ISM

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The spatial power spectrum of the H I 21 cm intensity in the Small Magellanic Cloud (Stanimirović et al. 1999) is
a power law over scales as large as those of the SMC itself. It was interpreted as due to turbulence by Goldman (2000) and by Stanimirović & Lazarian (2001). The question is whether the power spectrum is indeed the result of a dynamical turbulence or is merely the result of a structured static density. In the turbulence interpretation of Goldman (2000) the turbulence was generated by the tidal effects of the last close passage of the LMC about 0.2 Gyr ago. The turbulence time-scale was estimated by Goldman to be 0.4 Gyr, so the turbulence has not decayed yet. Staveley-Smith et al. (1997) observed in the SMC about five hundreds of H\alpha super shells. Their age is more than an order of magnitude smaller than the turbulence age. Therefore, if the turbulence explanation holds, their observed radial velocities should reflect the turbulence in the gas in which they formed. In the present work we analyze the observed radial velocities of the super shells. We find that the velocities indeed manifest the statistical spatial correlations expected from turbulence. The turbulence spectrum is consistent with that obtained by Goldman(2000).

Oral contribution, published in IAUS 237, Triggered Star Formation in a Turbulent ISM, eds. B.G. Elmegreen & J. Palouš
Available from astro-ph/0703793

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Chandra Observations of Supernova 1987A

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We have been monitoring Supernova (SN) 1987A with Chandra X-Ray Observatory since 1999. We present a review of previous results from our Chandra observations, and some preliminary results from new Chandra data obtained in 2006 and 2007. High resolution imaging and spectroscopic studies of SN 1987A with Chandra reveal that X-ray emission of SN 1987A originates from the hot gas heated by interaction of the blast wave with the ring-like dense circumstellar medium (CSM) that was produced by the massive progenitor’s equatorial stellar winds before the SN explosion. The blast wave is now sweeping through dense CSM all around the inner ring, and thus SN 1987A is rapidly brightening in soft X-rays. At the age of 20 yr (as of 2007 January), X-ray luminosity of SN 1987A is \( L_X \sim 2.4 \times 10^{36} \) ergs s\(^{-1}\) in the 0.5–10 keV band. X-ray emission is described by two-component plane shock model with electron temperatures of \( kT \sim 0.3 \) and 2 keV. As the shock front interacts with dense CSM all around the inner ring, the X-ray remnant is now expanding at a much slower rate of \( v \sim 1400 \) km s\(^{-1}\) than it was until 2004 (\( v \sim 6000 \) km s\(^{-1}\)).

Available from arXiv:0704.02

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The Reverse Shock of SNR 1987A

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The reverse shock of supernova remnant (SNR) 1987A emits in H\(\alpha\) and Ly\(\alpha\), and comes in two flavors: surface and interior. The former is due to direct, impact excitation of hydrogen atoms crossing the shock, while the latter is the result of charge transfer reactions between these atoms and slower, post-shock ions. Interior and surface emission are analogous to the broad- and narrow-line components observed in Balmer-dominated SNRs. I summarize a formalism to derive line intensities and ratios in these SNRs, as well as a study of the transition zone in supernova shocks; I include an appendix where I derive in detail the ratio of broad to narrow H\(\alpha\) emission. Further study of the reverse
shock emission from SNR 1987A will allow us to predict when it will vanish and further investigate the origins of the interior emission.

Available from arXiv:0704.1304

Fifteen Years of High-Resolution Radio Imaging of Supernova 1987A
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Supernova 1987A in the Large Magellanic Cloud provides a spectacularly detailed view of the aftermath of a core-collapse explosion. The supernova ejecta initially coasted outward at more than 10% of the speed of light, but in 1990 were observed to decelerate rapidly as they began to encounter dense circumstellar material expelled by the progenitor star. The resulting shock has subsequently produced steadily brightening radio synchrotron emission, which is resolved by the Australia Telescope Compact Array (ATCA) into an expanding limb-brightened shell. Here we present 15 years of ATCA imaging of Supernova 1987A, at an effective angular resolution of 0.4\(''\). Over this period, we find that the radio remnant has gradually accelerated in its expansion, from \(~3600\) km s\(^{-1}\) in 1992 to \(~5200\) km s\(^{-1}\) at the end of 2006. The published diameters of the evolving X-ray shell have been \(~15\%\) smaller than the corresponding radio values, but a simultaneous Fourier analysis of both radio and X-ray data eliminates this discrepancy, and yields a current diameter for the shell in both wave-bands of \(~1.7\)\(''\). An asymmetric brightness distribution is seen in radio images at all ATCA epochs: the eastern and western rims have higher fluxes than the northern and southern regions, indicating that most of the radio emission comes from the equatorial plane of the system, where the progenitor star’s circumstellar wind is thought to be densest. The eastern lobe is brighter than and further from the supernova site than the western lobe, suggesting an additional asymmetry in the initial distribution of supernova ejecta.

Available from arXiv:0705.0057

SN Shock Evolution in the Circumstellar Medium surrounding SN 1987A
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We study the structure of the circumstellar medium surrounding SN 1987A in the equatorial plane. Furthermore, we study the evolution of the SN shock within this medium during the first 25 years, and the resulting hard X-ray and radio emission from the remnant.

Available from arXiv:0705.0483
and from http://astro.uchicago.edu/~vikram/sn87a.html
Explosive and Quiescent Stellar Mass Loss, and The Origins of Dust in the Universe

Electronic versions are available of most of the talks and posters presented at the following two sessions at the UK National Astronomy Meeting in Preston, on 17 April 2007:


These sessions were organised by the UK Working Group on Evolved Stars, and cover a range of topics including evolved stars and dust in the Magellanic Clouds

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See also http://www.astro.keele.ac.uk/e-stars