IAU Symposium 190 “New Views of the Magellanic Clouds”

Sidney van den Bergh kindly made the conclusions of his closing summary from IAU Symp. 190 available for publication in MCNews. The full text of his summary will appear in the conference proceedings.

IAU Symposium 190: Conclusions

• Geometrical distance determinations, based on observations of SN 1987A and of the detached eclipsing binary HV 2274, yield distance moduli of \((m - M)_0 = 18.58 \pm 0.05\) and \((m - M)_0 = 18.44 \pm 0.07\), respectively for the Large Magellanic Cloud. These values are both compatible with the canonical value \((m - M)_0 = 18.5 \pm 0.1\), which corresponds to a distance of 50 kpc.
• The great burst of cluster formation that started in the LMC 3-5 Gyr ago is only weakly reflected in the rate at which field stars were formed. This strongly suggests that the rate of cluster formation is not a good diagnostic for the overall rate of star formation. The observation that the present rate of cluster formation, normalized to the rate of star formation in the LMC, is more than two orders of magnitude greater than it is in the Local Group dwarf irregular IC 1613 supports this conclusion.

• Tidal interactions between the LMC and SMC that occurred ~ 0.2 Gyr and ~ 1.5 Gyr ago produced the Bridge and the Magellanic Stream, respectively. It is presently not clear if the LMC and SMC were closely bound between 3 Gyr and 13 Gyr ago. Improved proper motions are urgently required to constrain their orbital history.

• Observations of microlensing events strongly suggest that they are not produced by objects located in the Galactic halo. The enormous data base provided by the EROS, MACHO and OGLE consortia is proving to be a gold mine for the study of variable stars in the Clouds of Magellan.

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MCNews Subscriptions

We are pleased to report that the number of subscribers of the Magellanic Clouds Newsletter reached 400 last week. This number reflects very nicely the large and active Magellanic Clouds research community. Readers of MCNews reside in 28 countries. Abstracts from researchers in 23 countries have been published so far. For more information about the geographical distribution please take a look at our statistics page at

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We greatly appreciate your interest in and contributions to MCNews.

Thank you.

Eva Grebel & You-Hua Chu
Numerical Simulation of Asymmetric Spiral Structure in the Large Magellanic Cloud

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We have constructed a dynamical model of the Large Magellanic Cloud based on the new propagating star formation scheme of Gardiner, Turfus, & Wang (1998) to examine the effects of an off-center perturbation on the global distribution of the gas and star formation activity. The simulation generates an asymmetric spiral structure which appears to be consistent with the pattern of large-scale star formation activity and recent observations of the neutral gas distribution. We suggest that the presence of a dual asymmetry in the offset bar and spiral structure is a major factor governing the global structure, dynamics and evolution of the LMC.

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For preprints, contact ltg@omega.sunmoon.ac.kr
Also available from the URL http://user.chollian.net/~gardiner/pub1.htm
or by anonymous ftp at mso.anu.edu.au, /pub/putman/LMC/LMC.tar.Z

Star and Cluster Formation in the Large Magellanic Cloud

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A great burst of cluster formation increased the rate at which open clusters were formed in the Large Magellanic Cloud 3–5 Gyr ago by at least an order of magnitude. On the other hand the rate of star formation $\sim 4$ Gyr appears to have increased by a factor of only 2–4. This shows that the rate of cluster formation is not a good tracer of the rate at which stars are formed. Normalized to the same rate of star formation, the Large Cloud is presently forming / 600 times more star clusters than the Local Group dwarf irregular IC 1613. The high rate of cluster formation in merging gas-rich galaxies suggests that strong shocks might favor the formation of clusters.

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Far-Ultraviolet Imaging of the Field Star Population in the Large Magellanic Cloud with HST

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We present an analysis of the deepest pure-UV observations with the highest angular resolution ever performed, a set of 12 exposures with the HST WFPC2 and F160BW filter obtained in parallel observing mode, which cover \~{}12 square arcminutes in the LMC, North of the bar and in the “general field” regime of the LMC. The 341 independent measurements of 198 objects represent an accumulated exposure of \( \geq 2 \cdot 10^4 \) sec and reveal stars as faint as \( m_{UV} \simeq 22 \) mag. The observations show that \( \sim 2/3 \) of the UV emission from the LMC is emitted by our HST-detected UV stars in the field, \textit{i.e.}, \textit{not} in clusters or associations. We identified optical counterparts in the ROE/NRL photometric catalog for \( \sim 1/3 \) of the objects. The results are used to discuss the nature of these UV sources, to estimate the diffuse UV emission from the LMC as a prototype of dwarf galaxies, and to evaluate the contamination by field stars of UV observations of globular and open clusters in the LMC. We find that the projected density of UV stars in the general field of the LMC is a few times higher than in the Galactic disk close to the Sun. Combining our data with observations by UIT allows us to define the stellar UV luminosity function from \( m_{UV} = 8 \) to 18 mag, and to confirm that the field regions in the LMC have been forming stars at a steady rate during the last 1 Gyr, with an IMF close to the Salpeter law.

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HST WFPC2 Color-Magnitude Diagrams of Halo Globular Clusters in M33: Implications for the Early Formation History of the Local Group

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We have constructed color-magnitude diagrams (CMDs) for ten globular clusters in the halo of the nearby spiral galaxy M33 based on Hubble Space Telescope Wide-Field Planetary Camera 2 observations in the F555W (\(~V\)) and F814W (\(~I\)) filters. These data reveal the morphology of the HB and allow us to estimate the cluster metallicity using the shape and color of the red giant branch. The principal result we report herein is that 8 of the 10 clusters possess exclusively red HB morphologies yet their metallicities are as metal-poor as \([Fe/H] = -1.6\). Indeed, these 8 clusters present basically only giant branch clumps reminiscent of intermediate age star clusters in the Magellanic
Clouds. In addition, two of the clusters form a second parameter pair which have similar metallicities but very disparate HB types. Under the assumption that cluster age is the global second parameter, the average age of halo globular clusters in M33 appears to be a few Gyr younger than halo clusters in the Milky Way. Using the observed properties of HB stars in M31 and M33 along with published main-sequence turnoff ages for the globular clusters in the Milky Way, LMC, SMC, and the Sagittarius dwarf spheroidal (Sgr), we attempt to sketch the early formation history of these galaxies. This indicates that the Milky Way, M31, M33, the LMC, and Sgr all experienced their first epoch of cluster formation soon after the Big Bang. Three to four Gyr later, the SMC began to form its first generation of clusters; the bulk of the M33 clusters formed later still. We note that the halo clusters in M33 formed over a much larger time period than those in the Milky Way and M31.

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The cluster pair SL 538 & NGC 2006

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We studied in detail the binary cluster candidates SL 538 and NGC 2006 in the Large Magellanic Cloud (LMC). This cluster pair is located in the northwestern part of the large OB association LH 77 in supergiant shell LMC 4. A third star cluster, KMHK 1019, is located within 5' from the cluster pair. Our study is the first age determination of SL 538 and NGC 2006 that is based on CMDs. We derived an age of 18 ± 2 Myr for SL 538, 22.5 ± 2.5 Myr for NGC 2006, and 16 Myr for KMHK 1019. Thus the three clusters are (nearly) coeval. We identified Be star candidates and find the same ratio N(Be)/N(B) for the components of the binary cluster (12%) while the amount of Be stars detected in KMHK 1019 (5%) and in the surrounding field (2%) is considerably lower. Since Be stars are usually rapid rotators this may indicate intrinsically higher rotational velocities in the components of the cluster pair. Also the IMF derived from the CMDs shows the same slope for both SL 538 and NGC 2006 and is consistent with a Salpeter IMF. An estimation of the cluster masses based on the IMF slopes showed that both clusters have similar total masses. These findings support joint, near-simultaneous formation of the cluster pair in the same giant molecular cloud.

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Be Stars in and Around Young Clusters in the Magellanic Clouds

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We present the results of a search for Be stars in six fields centered on the young clusters NGC 330 and NGC 346 in the SMC, and NGC 1818, NGC 1948, NGC 2004 and NGC 2100 in the LMC. Be stars were identified by differencing R band and narrow-band H\alpha CCD images. Our comparatively large images provide substantial Be star populations both within the clusters and in their surrounding fields. Magnitudes, positions and finding charts are given for the 224 Be stars found. The fraction of Be stars to normal B stars within each cluster is found to vary significantly although the average ratio is similar to the average Be to B star ratio found in the Galaxy. In some clusters, the Be star population is weighted to magnitudes near the main sequence turn-off. The Be stars are redder in $V-I$ than normal main-sequence stars of similar magnitude and the redness increases with increasing H\alpha emission strength.

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

Evolutionary synthesis modeling of red supergiant features in the near–infrared

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We present evolutionary synthesis models applied to near–infrared spectral features observed in the spectra of young Magellanic Cloud clusters and starburst galaxies. The temporal evolution of the first and second overtones of CO at 2.29 \textmu m (2–0 bandhead) and 1.62 \textmu m (6–3 bandhead) and of the $(U-B)$, $(B-V)$ and $(J-K)$ colors are investigated.

We find that the current evolutionary tracks of massive stars with sub–solar chemical composition in the red supergiant phase are not reliable for any synthesis of the temporal evolution of infrared stellar features.

The high sensitivity of the selected infrared features to the atmospheric parameters of cool stars allows us to place constraints on the temperature and the fraction of time spent in the red part of the Hertzsprung–Russell diagram by massive stars during their core–helium burning phase.

We derive a set of empirically calibrated spectrophotometric models by adjusting the red supergiant parameters such that the properties of the observed templates are reproduced.

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Also available from the URL http://www.obs-mip.fr/omp/astro/people/schaerer/
Pre-Supernova ring around PSR0540-69

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SNR0540-69 is a supernova remnant in the LMC, harbouring a young (\(\tau \sim 1600\text{yrs}\)) radio/optical/X-ray pulsar (\(P=50\text{ ms}\)). Ground based \(H\alpha\) imaging of the region has shown a unique spiral-like structure centered around the pulsar. In narrow band HST imaging, the feature seems resolved in a ring-like structure, probably ejected by the progenitor star in a pre-supernova phase (\(\geq 10^4\text{yrs}\) ago).

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New HST Observations of High Velocity Ly\(\alpha\) and H\(\alpha\) in SNR 1987A

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We describe and model high velocity (\(\approx 15,000\ \text{km s}^{-1}\)) Ly\(\alpha\) and H\(\alpha\) emission from supernova remnant 1987A seen in September and October 1997 with the Space Telescope Imaging Spectrograph. Part of this emission comes from a reverse shock located at \(\approx 75\%\) of the radius of the inner boundary of the inner circumstellar ring and confined within \(\pm 30^\circ\) of the equatorial plane. Departure from axisymmetry in the Ly\(\alpha\) and H\(\alpha\) emission correlates with that seen in nonthermal radio emission. We also see diffuse high velocity Ly\(\alpha\) emission from supernova debris inside the reverse shock that may be due to excitation by nonthermal particles accelerated by the shock.

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56Ni dredge-up in Supernova 1987A

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We use early-time observations of He(10830 Å) to measure the extent of upward mixing of radioactive material in SN1987A. This work develops and extends the work of Graham (1988), and places constraints on actual explosion models. The presence of the He(10830 Å (2s^3S→2p^3P) line at \( \geq 10 \) days post-explosion implies re-ionisation by \( \gamma \)-rays from upwardly-mixed radioactive material produced during the explosion. Using the unmixed explosion model 10H (Woosley 1988) as well as mixed versions of it, we estimated the \( \gamma \)-ray energy deposition by applying a purely absorptive radiative transfer calculation. The deposition energy was used to find the ionisation balance as a function of radius, and hence the \( 2^3S \) population density profile. This was then applied to a spectral synthesis model and the synthetic spectra were compared with the observations. Neither model 10H nor the mixed version, 10HMM, succeeded in reproducing the observed He(10830 Å line. The discrepancy with the data found for 10HMM is particularly significant, as this model has successfully reproduced the X-ray and \( \gamma \)-ray observations and the UVOIR light curve. We find that a match to the He line profile is achieved by reducing the extent of mixing in 10HMM. Our reduced-mixing models also reproduce the observed \( \gamma \)-ray line light curves and the iron-group velocities deduced from late-time infrared line profiles. We suggest that the He line method provides a more sensitive measure of the extent of mixing in a type II supernova explosion.

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Iron Opacity and the Pulsar of Supernova 1987A

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Neutron stars formed in Type II supernovae are likely to be initially obscured by late-time fallback. Although much of the late-time fallback is quickly accreted via neutrino cooling, some material remains on the neutron star, forming an atmosphere which slowly accretes through photon emission. In this paper, we derive structure equations of the fallback atmosphere and present results of one-dimensional simulations of that fallback. The atmosphere remaining after neutrino cooling (\( L_\nu \)) becomes unimportant (\( L_\nu < L_{\text{Edd, e}} \), the Compton Eddington limit) is only a fraction of the total mass accreted (\( < 10^{-8} M_{\odot} = 10^{-9} M_{\odot} \)). Recombined iron dominates the opacity in the outer regions leading to an opacity \( 10^3 - 10^4 \) times higher than that of electron scattering alone. The resultant photon emission of the remnant atmosphere is limited to \( < 10^{-3} L_{\text{Edd, e}} \). The late-time evolution of this system leads to the formation of a photon-driven wind from the accretion of the inner portion of the atmosphere, leaving, for most cases, a bare neutron star on timescales shorter than a year. The degenerate remnant of 1987a may not be a black hole. Instead, the fallback material may have already accreted or blown off in the accretion-driven wind. If the neutron star has either a low magnetic field or a low rotational
spin frequency, we would not expect to see the neutron star remnant of 1987a.

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We present and discuss theoretical predictions concerning the pulsational properties of Classical Cepheids. Masses and luminosities provided by stellar evolutionary calculations are used as input parameters of nonlinear, nonlocal and time-dependent convective pulsing models and accurate determinations of both the blue and red edge of the instability strip are derived, together with theoretical light curves for a suitable grid of models. The computations have been performed for three different chemical compositions ($Y=0.25$, $Z=0.004$; $Y=0.25$, $Z=0.008$; $Y=0.28$, $Z=0.02$), taken as representative of Cepheids in the Magellanic Clouds (MCs) and in the Galaxy.

Bolometric light curves have been transformed into visual and near-infrared magnitudes and the intensity-weighted mean magnitudes of the pulsator over a full pulsation cycle ($<M_V>$ and $<M_K>$, respectively) are obtained. We derive that either in the logP--$M_V$ and in the logP--$M_K$ planes the predicted edges of instability strip are in excellent agreement with the observed distribution of Galactic and Magellanic Cepheids, providing a preliminary estimate of the distance to these galaxies. Moreover, we show that the models are in agreement with several empirical Period-Luminosity (PL) relations given in the literature, even though the theoretical distribution in logP--$M_V$ plane is better represented by a quadratic PL relation. We also show that both the zero-point and the slope of the predicted PL relations are significantly dependent on metallicity, with the amplitude of the metallicity effect decreasing at the longer wavelength. At variance with several empirical suggestions appeared in the literature, we find that at fixed period the metal-rich pulsators should be fainter than the metal-poor ones.

Tight Period-Luminosity-Color (PLC) relations are derived for both visual and near-infrared photometric bands. Also in this case the effect of metallicity decreases with increased wavelength. From a preliminary use of our relations to Magellanic Cepheids, we confirm that, within the statistical errors, the distance modulus obtained from different PL and PLC relations is marginally correlated with the adopted relation, but the associated uncertainty decreases when infrared magnitudes are taken into account.

Finally the whole pulsational scenario is briefly discussed in light of the adopted evolutionary framework.

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The Optical Gravitational Lensing Experiment. Short Distance Scale to the LMC.

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We present \textit{UBVI} photometry of the eclipsing binary HV2274 – the system which has been recently used for distance determination to the LMC by Guinan \textit{et al.} (1998). We determine the interstellar reddening to the star, \(E(B-V) = 0.149 \pm 0.015\) mag, based on observed colors of the star. This value is in excellent agreement with the mean reddening towards HV2274 obtained from photometry of the red clump stars in the surrounding field. The reddening is almost twice as large as determined by Guinan \textit{et al.} (1998).

We discuss the consequences of reddening underestimate. Most likely HV2274 is located much closer with the distance modulus to the star and the LMC: \(m - M = 18.22 \pm 0.13\) mag supporting the short distance scale to the LMC. Such a distance modulus is in excellent agreement with the recent distance determinations with RR Lyr and red clump stars. Another possibility is larger effective temperature of both components of the system by about 3000 K.

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Abstracts of Non-Refereed Papers

AGB stars in the Large Magellanic Cloud as seen with DeNIS

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This is the presentation of a sample of data of the Large Magellanic Cloud (LMC) covering a region of 2.5\degree in right ascension from the DeNIS (Deep Near Infrared Southern Sky Survey) survey.


For preprints, contact mrcioni@strw.leidenuniv.nl
Young Magellanic Cloud Clusters (< 1 Gyr):
Census, Properties, Star Formation History

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We report preliminary results from an automated cluster survey of the Magellanic Clouds aimed at improving the cluster census and at deriving cluster properties from their resolved stellar content. The survey is tripling the number of known clusters. The clusters age distribution shows similar peaks at 100–200 Gyr in LMC and SMC, coincident with the closest encounter of the Clouds and perigalacticon.

For preprints, contact grebel@ucolick.org

Star Clusters in the Magellanic Type Irr Galaxy NGC 4449

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We compare the luminosity function of star clusters in the LMC and NGC 4449: a IBm/Sm type galaxy very similar in appearance and luminosity ($M_B = -18.5$) to the LMC ($M_B = -18.4$.) The brightest of several hundred clusters in NGC 4449 have $M_V = -10$, (assuming a distance of 3.9 Mpc) comparable to the brightest clusters in the LMC.

For preprints, contact seitzer@astro.lsa.umich.edu
Meeting Announcement

IAU Coll. No. 176
The Impact of Large-Scale Surveys on Pulsating Star Research

Date and venue
August 8 – 12, 1999, Budapest, Hungary

Outline of the scientific program:
• Large-Scale Surveys — Techniques, Methods, Data Flow
• Cepheids — Physical Properties, Distance Indicators
• RR Lyrae and SX Phe Stars — Physical Properties, Distance Indicators
• Small-Amplitude Pulsators — B-type, Delta Scuti, Ap Stars
• High-Luminosity Pop. II Stars — Regular and Irregular Pulsations
• Non-stationary Pulsations — Blazhko-effect, Mode Switching
• Theoretical Works — Recent Results
• Pulsating Stars — Broader Astrophysical Aspects

Preliminary list of speakers
Bohdan Paczyński (USA), Janusz Kalluży (Poland), Michael Albrow (New Zealand), Michael Perryman (Netherlands), Jean-Philippe Beaulieu (France), Jesper Storm (Germany), Douglas Welch (Canada), Dimitar Sasselov (USA), Dante Minniti (USA), Alistair Walker (Chile), Mario Mateo (USA), Conny Aerts (Belgium), Luis Balona (South Africa), Gerald Handler (Austria), Hans Kjeldsen (Denmark), Cecile Loup (France), Karen Pollard (New Zealand), Alfred Gautschy (Switzerland), Allan Swegart (USA), Gustav Tammann (Switzerland)

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Please pre-register by November 1 (form available from the above addresses) to help us to estimate the number of participants. Please note that the meeting starts on Sunday (8th) and ends on Thursday (12th). We start on Sunday because of the Formula I race in Budapest is scheduled on Aug. 13-15. Because of the much higher prices during the race, and the great difficulties in getting accommodation for non-Formula I guests in Budapest, we recommend to those who wish to stay after the conference, to make arrangements well before their trip (we will give information in the Second Announcement on programs, hotels, and sites to visit). We are in the process of reserving 3 hotels for the participants, which will offer a special conference rate and bussing. In case of overbooking, we follow the general rule of 'first come first served'.