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Contents of this newsletter

From the editor

This issue covers two months of publications and is dominated by η Car, other LBVs and B[e] stars. Other papers tell us about massive stars in the Galactic Center and R136, OB stars, polarimetry, wind models and [WC] central stars of Planetary Nebulae.

We also present a book and remind readers about future meetings: two special sessions during IAU symposium 193 in Mexico (on HD5980 and on the XMEGA campaign) as well as IAU colloquium 175 in Spain in June 1999 (on Be stars).

Accepted Papers

On the Multiplicity of η Carinae

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The nebula around the luminous blue variable η Car is extremely N-rich and C,O-poor, indicative of CNO-cycle products. On the other hand, the recent HST-GHRS observation of the nucleus of η Car shows the spectrum of a star with stellar-wind lines of C II, C IV, Si II, Si IV etc. The spectrum is very similar to those of the LBV star P Cygni and of WN9/Ofpe stars. This line spectrum is indicative of a photosphere which is only mildly enhanced by CN-cycle products. This situation of a nebula that is chemically more advanced than the central star cannot be reached by the evolution of a single star. The dichotomy shows that the star whose spectrum now dominates the nucleus, was not the star that ejected the nebula. We discuss this evidence for multiplicity and combine it with the information about the 5.5 year periodicity in the emission lines.

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The X-ray lightcurve of Eta Carinae

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Following the proposal by Damineli that the central object of Eta Carinae may be an early-type binary, we perform numerical simulations of the X-ray emission from colliding stellar winds. A synthetic lightcurve has been generated which qualitatively agrees with the recent X-ray variability, and provides further support for the binary model. In particular, the model predicts a rise in the observed X-ray emission towards periastron, followed by a sharp drop and subsequent recovery. This is indeed what is seen in the *RXTE* lightcurve, although some problems concerning the X-ray spectrum at periastron remain to be explained. The simulations suggest that the width of the periastron dip will provide strong constraints on the binary and stellar wind properties of the components of Eta Car.

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On the Formation of the Homunculus Nebula around η Carinae

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We have constructed an interacting winds scenario to account for the geometric and kinematic properties of the Homunculus in η Carinae as seen in recent HST observations. Winds from a giant eruption in 1840-1860 sweep into a small (10^{14} cm), dense ($\sim 10^{14}$cm^{-3}), two-solar-mass, near-nuclear toroidal ring. The external medium is uniform at $\sim$ 2000 particles cm^{-3}. The ring is all but destroyed by the winds in the eruption. Even so, it manages to provide a good deal of collimation to the mass ejected in the first 20 years. Subsequent weaker outflows ram into the outburst gas and initiate surface instabilities and wrinkles. Unlike earlier models, ours is in accordance with the observation that no large, extended disk-like distribution is seen around the nebula which could have collimated the bipolar lobes.

Models with cooling form essentially ballistic flows (that is, a pair of cones each with a spherical base) whose lateral edges become wrinkled by shear instabilities. A new aspect of the radiative models is the fragmentation of the dense ring, which may help to explain the thin, radial filamentary structure that is seen in the equatorial region of the Homunculus. Adiabatic models become very hot quickly, and explode through the nascent cones into the confining gas before the dense collar is destroyed. A pair of spherical lobes form. After 150 years the lobe walls are corrugated by shearing instabilities. These lobes morph into one large single balloon after about another 300 years.

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Line profile variability in the spectrum of the O(f) supergiant HD 192639

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We report the results of a medium-resolution spectroscopic investigation of the O(f) supergiant HD 192639. Particular attention is paid to the He II λ4686 line. This line displays strong profile variability on time scales of a few days, changing from a P-Cygni profile with a double-peaked emission component to a pure blue-shifted emission line. It appears that the variability of most of the absorption lines present in our spectra is correlated to the deformation of the He II λ4686 line and arises probably from a large scale structure in the low-velocity part of the stellar wind rather than from a photospheric phenomenon. We find that the time scale of the variability could be consistent with the estimated rotational period of HD 192639.

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Light variations of massive stars (α Cyg variables. XVI. The LMC supergiants R 85 (LBV) and R 110 (LBV) and the SMC supergiants R 42 and R 45

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Multi-colour photometry of four variable supergiants in the LMC and SMC, viz. R 85, R 110, R 42 and R 45, is searched for periods, studied and discussed. The suspected LBV R 85 is undoubtedly an active LBV, though not as spectacular as R 110. Their microvariations superimposed on the S Dor-activity are analyzed as well as those exhibited by R 42 and R 45. Often, a period search is difficult because of the very complicated microvariability. We suggest that this is caused by an intricate multi-cyclic behaviour combined with stochastic processes. The length of the strongest cyclicity in the power spectrum of R 42 (128 d) is of the order of the rotation period of late BA- type supergiants.

In connection with our findings described in the present paper and the previous ones, we discuss various competing

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An extraordinary cluster of massive young stars in the Milky Way's nucleus

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The mass distribution of newborn stars (the stellar initial mass function, or IMF) is key to the evolution of galaxies, as it determines whether a galaxy's interstellar medium is funneled predominantly into dim, long-lived, low-mass stars, as is the case in normal galactic disks, or into bright, short-lived, massive stars, as is perhaps the case in "starburst" nuclei. Our own Galactic nucleus is not a full-fledged starburst, but its star-formation rate per volume is nevertheless well above that of the Galactic disk (by a factor of $\sim 10^3$). Even so, the Milky Way's nuclear IMF remains uncertain, because high obscuration and the large background population of bright, elderly giant stars have impeded the detection of normal hydrogen-burning (or "main-sequence") stars. Our high-resolution infrared observations of a compact stellar cluster in the nucleus now reveal the presence of numerous young, massive main sequence stars, several of which may number among the Galaxy's most massive. Dwarfing all other known young Galactic clusters, the "Arches" cluster may in fact be a weaker analog of the "super star-clusters" found in starburst nuclei.

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Preprints available on the web at http://www.astro.ucla.edu/ figer/papers.html

High State of Hα Emission Activity of the Herbig Be Star HD 200775

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We present the results of high-resolution spectroscopic observations of the pre-main-sequence Herbig Be star HD 200775 obtained between September 1994 and February 1998. Strong variations of the Hα line associated with an extended period of strong emission during summer and fall 1997 have been observed. The line equivalent width took on the highest value reported in the last 20 years. A review of the observational literature dating back to 1977 indicates periodic behavior of the Hα equivalent width with a period of 3.68 years. These variations might be due to interaction between the stellar wind and the protostellar envelope, as suggested previously by Beskrovnaya et al. (1994, A&A, 287, 564), or to an effect of a possible close companion, such as those detected in some classical Be stars. The next high emission state is predicted to occur in the first half of 2001. We emphasize the importance of coordinated photometric and high-resolution spectroscopic observations for further understanding of the star's behavior.

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Numerical simulations of wind bow shocks produced by runaway OB stars

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We present the results of a study focused on the morphology and dynamical evolution of wind bow shocks produced by massive runaway stars in the diffuse interstellar medium. A revision of current analytical models describing the shape and physical parameters of a wind bow shock is proposed, motivated by the recognition that the shocked stellar wind does not need to incorporate into the bow shock as a result of its long cooling time. The semi-analytical expressions we derive, suggest that actual surface densities and velocity patterns in wind bow shocks differ significantly from those previously predicted using the assumption of instantaneous cooling of the shocked gas.

To test the general validity of these simplified models and to obtain a more realistic picture of the bow shock characteristics, we have carried out a number of two-dimensional numerical simulations. We have examined the influence of the stellar wind strength, the ambient interstellar density, and the relative velocity of the star on the resulting structures. Particular attention is paid to the role of the physical ingredients used to model the dynamics of the gas, especially the effects of finite cooling times and thermal conduction. The numerical simulations, while confirming in general terms the validity of our simplified, semi-analytical approach, reveal a wealth of details in the structure and evolution of wind bow shocks.

By exploring a representative range of the parameter space, we show that the interaction of the stellar wind with the ambient medium can give rise to a remarkable diversity of structures, even with moderate changes in the basic input parameters. Depending on these, a bow shock may be stable or unstable, have a simple or a layered structure with different density and temperature domains, or may not form at all. In this context, we briefly discuss the potential of observations of wind bow shocks as diagnostic tools of the stellar wind of the runaway star and the medium in which it travels.

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Near–Infrared Classification Spectroscopy: H–band Spectra of Fundamental MK Standards

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We present a catalogue of H–band spectra for 85 stars of approximately solar abundance observed at a resolving power of 3000 with the KPNO Mayall 4m FTS. The atlas covers spectral types O7–M5 and luminosity classes I-V as defined on the MK system. We identify both atomic and molecular indices and line–ratios which are temperature and luminosity sensitive allowing spectral classification to be carried out in the H–band. The line ratios permit spectral classification in the presence of continuum excess emission, which is commonly found in pre–main sequence and evolved stars. We demonstrate that with spectra of $R = 1000$ obtained at $SNR > 50$ it is possible to derive spectral types within ± 2 subclasses for late–type stars. These data are available electronically through the Astronomical Data Center in addition to being served on the World–Wide–Web.

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Near-Infrared H-band Features in Late-O and B Stars

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We examine the spectral characteristics of normal OB stars with high signal-to-noise (>120) H (1.6 μm) band spectra at a resolution of 2000. We find several atomic lines to vary smoothly with stellar temperature as first shown by Blum et al. (1997). However, we find a previously unreported, significant

variation in the strength of some of these lines with stellar luminosity. B supergiant stars show stronger HeI and weaker Br 11 as compared to low luminosity B dwarf stars of the same spectral class. It is for this reason that luminosity class must also be determined to obtain an accurate spectral type for a given star using H-band spectra. We suggest a method for estimating the spectral type and luminosity of an OB star over the wavelength range from 1.66 to 1.72 μm using hydrogen Brackett 11 at 1.681 μm, HeI at 1.700 μm and HeII at 1.693 μm. The use of the near-infrared spectral range for classification has obvious advantages over optical classification when applied to heavily reddened stars, such as in star forming regions or deeply embedded lines of sight within the plane of the Galaxy, such as the galactic center. Furthermore, the H-band is less likely to be contaminated by infrared excess emission, which is frequently seen around massive young stellar objects beyond 2 μm.

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http://highz.as.arizona.edu/∼mhanson/ABSTRACTS/hanson9.html

V 439 Cyg: the smallest LBV?

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The emission line star V 439 Cyg (MWC 1015) dramatically changed its spectrum from late to early type in a few decades with line variability present at various levels. The star is a member of the peculiar young open cluster Berkeley 87 that contains, besides V 439 Cyg, a few peculiar objects in a late stage of stellar evolution. A strong IR source is associated with the region surrounding V 439 Cyg. The star has a peculiar position in the cluster HR diagram possibly due to anomalous reddening. We have analysed a collection of historical observations and collected new spectroscopic and photometric data on this unique object. We demonstrated that V 439 Cyg is at present a hot star surrounded by an H_α nebula that is probably the remnant of one or more shell ejections. The spectral and photometric variability exhibited by the star in the last decades resembles that of the LBV stars although at a somewhat lower level of activity. The indication that the star had a Mira-like appearence in 1941, meaning that it was at that time of red colour with a measurable pulsation period, could imply that a dynamical instability had already set in possibly culminating in a shell ejection. This created a pseudo-photosphere that was observed in the 1958 spectrum. The age of the cluster and the spectrum of the star in the present day hot phase rules out the possibility that we have observed a post-AGB PN ejection; on the other hand, given the smaller amount of mass apparently ejected in the outburst compared with other LBVs, we have postulated that V 439 Cyg is a star of smaller mass than a classical LBV star. We have tried to make some hypothesis about the stellar mass in the light of the most recent evolutionary models for massive stars, concluding that the V 439 Cyg scenario is compatible with that of a star having an initial mass $\simeq$40 $M_\odot$.

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Emission line profile shapes from anisotropic resonance line scattering in planar equatorial disks

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The consequences of anisotropic resonance line scattering for the emission profiles of equatorial disks are considered. In particular the opportunity to infer the disk velocity field owing to the anisotropic scattering is discussed. Analytic expressions for the profile shapes are derived for the cases of constant expansion and rotation, and numerical results are given for more realistic disk velocity fields of linear expansion and Keplerian rotation. The essential result is that the anisotropic line scattering produces a different profile signature in expanding disks as compared to rotating disks, owing to the difference in the isovelocity pattern of the two cases and how the two respective patterns relate to the scattering geometry. Unlike the spherical case discussed in a preceding paper, the anisotropic effects are more significant (up to 10–20%) in disk geometries because the degree of stellar occultation depends on viewing inclination. The key to using the formulae presented here is to obtain profiles of lines that have differing degrees of anisotropic scattering. In particular, strong doublets of Lithium-like atoms (e.g., CIV 1548,1550, MgII 2796, 2803, CaII 3935, 3969 to name a few) are well-suited for comparison, with the long wavelength component scattering isotropically and the short wavelength component being partially dipole scattering. Consideration of such doublets are advantageous in that the two components arise from the same spatial location in the flow, whereas the spatial coincidence of formation for two completely different lines is not assured. Owing to several simplifying assumptions, direct application of the results presented here to observations requires somewhat restrictive conditions, yet the diagnostic potential of the method does appear promising, especially for multiplets.

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The interstellar medium in the environs of O-type stars

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We analyze the distribution of the neutral gas in the neighbourhood of four southern O-type stars based on observations of the 21-cm HI line. These data disclose HI bubbles probably associated with the stars HD 112244 [O8.5Iab(f)], HD 155913 [O5Vn((f))], HD 175754 [O8II((f))] and HD 175876 [O6.5III(n)(f)]. The dimensions of these bubbles are in the range 90–170 pc and their expansion velocities are low, about 10 km s^{-1}, implying dynamical ages of (3–6)$\times 10^6$ yr. Only a few percent of the mechanical energy of the stellar wind is transformed into kinetic energy of the shells. Their origin and the contribution of other early type stars to the formation of these bubbles are discussed. Particularly, it is suggested that HD 155913 belongs to an unknown OB association that could also have contributed in the formation of the HI bubble surrounding this star. These new HI bubbles resemble HI bubbles surrounding Wolf-Rayet stars. The presence of stellar wind bubbles associated

with O-type stars supports an interpretation where the massive progenitor of the WR stars are also responsible for the formation of the HI bubbles detected around WR stars.

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Dissipative Models of Colliding Stellar Winds: I. Effects of Thermal Conduction in Wide Binary Systems

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The influence of electron thermal conduction on the 2D gas dynamics of colliding stellar winds is investigated. It is shown that due to the nonlinear dependence of the electron thermal flux on the temperature, the preheating zones, where the hot gas in the interaction region heats the cool winds in front of the shocks, have finite sizes. Dependence on the dimensionless parameters of the problem of the structure of the flow in the interaction region is studied and a simple expression is derived for the size of the preheating zones at the axis of symmetry. It is shown that small values of the thermal conductivity do not suppress the Kelvin-Helmholtz instability if the adiabatic flow is subject to it. Further studies, both numerical and analytical, in this direction are of great interest. The influence of thermal conduction on the X-ray emission from the interaction region is also estimated.

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HST UV measurements of wind structure and velocities in Local Group OB stars

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Archival *HST* FOS and GHRS data sets have been used to collect ultraviolet evidence for large- and small-scale stellar wind structure in extragalactic Local Group OB stars (i.e. SMC, LMC including R136, M 31, M 33, and NGC 6822). By comparison to previous studies of Galactic OB stars, wind activity is principally diagnosed in individual spectrograms via the presence of 'narrow absorption components' and saturated 'black' absorption troughs in the resonance line doublets. Their characteristics broadly suggest that these stars share the same physical mechanisms for perturbing the winds as those that act in Galactic stars. Both these spectral indicators are also used to provide reliable measures of wind terminal velocities. These velocities are directly compared to previously published Galactic values, without reliance on model profile fitting. Relative to Galactic OB stars, the most discrepant terminal velocities (and wind line profiles) are due to *main-sequence* early O-type stars in the SMC.

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Repetitive structure in the stellar wind of HD 93843: a normal O-type star

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We present the results from a 28-day *IUE* time-series campaign monitoring the stellar wind of the O5-type giant HD 93843. The principal aim was to study variability in the wind of a star with a normal projected rotation velocity. Systematic changes are identified, amidst continuous line-profile variability, in the absorption troughs of the Si IV and N V resonance lines. The patterns observed have characteristic time-scales of several days, and are mimicked by fluctuations (of several 100 km s^{-1}) in the blue wings of the saturated C IV P Cygni profile.

Fourier analysis provides support for the repeatability of wind structures in HD 93843 on a 7.1-day 'period'. Power at this frequency is evident only at intermediate and high velocities (i.e., above $\sim$ 0.3 of the terminal velocity). The long modulation time scale suggests that changes in the star itself probably provide the physical source for triggering the onset of wind structure. Unfortunately the rotational, photometric, pulsational and magnetic properties of HD 93843 are too poorly constrained or known to permit a more detailed interpretation of the 7.1-day wind modulation in terms of potential inhomogeneities at the stellar surface. Nevertheless, our study demonstrates that the incidence of cyclic, possibly regular, stellar-wind variability is not restricted to rapid rotators. Comparisons with other OB stars which have exhibited repetitive wind changes on 'periods' of several days, suggest that the time-dependent UV properties of HD 93843 are more akin to those of the O4-type supergiant ζ Puppis.

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Hydrodynamic simulations of the colliding winds in Iota Orionis

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Two-dimensional hydrodynamic simulations of the colliding winds in the eccentric binary Iota Orionis (HR 1889; HD 37043) have been conducted. With the inclusion of radiative driving the realistic simulation of such a system becomes possible for the first time. The dynamics of the post-shock flow throughout the orbit is explored. Radiative inhibition and sudden radiative braking both occur, lowering the temperature of the post-shock gas. Instabilities in the collision region are ubiquitous, leading to a great deal of structure. Two separate models with different stellar mass-loss rates are

examined. In both models the colliding wind shock collapses onto the photosphere of the secondary around periastron, due to the imbalance between the wind momentum fluxes. However, the shock is able to detach from the surface of the secondary in the less extreme model as the secondary star heads towards apastron. A higher resolution simulation indicates that this result is currently resolution dependent.

The synthetic intrinsic X-ray emission is extremely dependent on the amount of cooling in the post-shock flow, and hence its nature changes substantially if the shock detaches. In such a case it is very soft at periastron, but much harder at apastron. During the former, the secondary star penetrates deep into the wind acceleration region of the primary, and the pre-shock velocity is reduced from $\sim 2000\mathrm{kms}^{-1}$ to $\sim 1000\mathrm{kms}^{-1}$. The post-shock density also substantially increases, resulting in very strong cooling. In comparison, at apastron the post-shock density is low, and the pre-shock velocity is high, resulting in a very adiabatic wind collision. Synthetic X-ray lightcurves show a minimum in the 0.4-10.0 keV *ASCA* band centered on periastron with a duration of a couple of days. If the shock detaches a reduction in the 0.1-0.5 keV *ROSAT* emission is also predicted. Such variation, if seen in 'real' data, may help in accurately determining the mass-loss rates of the stellar components.

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An Empirical Isochrone of Very Massive Stars in R136a

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We report on a detailed spectroscopic study of twelve very massive and luminous stars ($M \gtrsim 35 M_\odot$) in the core of the compact cluster R136a, near the center of the 30 Doradus complex. The three brightest stars of the cluster, *viz:* R136a1, R136a2 and R136a3, have been investigated earlier by de Koter, Heap, & Hubeny (1997). Low-resolution spectra (< 200 km·s^{-1}) of the program stars were obtained with the GHRS and FOS spectrographs on the *Hubble Space Telescope*. These instruments covered the spectral range from 1200 to 1750 Å and from 3200 to 6700 Å respectively. Fundamental stellar parameters were obtained by fitting the observations by model spectra calculated with the unified ISA-WIND code of de Koter et al. supplemented by synthetic data calculated using the program TLUSTY.

We find that the stars are almost exclusively of spectral type O3. They occupy only a relatively narrow range in effective temperatures between 40 and 46 kK. The reason for these similar $T_{\rm eff}$'s is that the isochrone of these very massive stars, which we determined to be at ~ 2 Myr, runs almost vertically in the HR-diagram. We present a quantitative method of determining the effective temperature of O3-type stars based on the strength of the O V λ1371 line.

Present-day evolutionary calculations by Meynet et al. (1994) imply that the program stars have initial masses in the range of $\mathrm{M_i} \sim 37$ to 76 $M_\odot$. The observed mass-loss rates are up to three (two) times higher than is assumed in these evolution tracks when adopting a metallicity Z = 0.004 (0.008) for the LMC. The high observed mass-loss rates imply that already at an age of ~ 2 Myr the most luminous of our program stars will have lost a significant fraction of their respective initial masses.

For the least luminous stars investigated in this paper, the observed mass loss agrees with the prediction by the theory of radiation-driven winds (Kudritzki et al. 1989). However, for increasing luminosity the observed mass loss becomes larger, reaching up to three to four times what is expected from the theory. Such an increasing discrepancy fits in with the results of de Koter et al. (1997) where an observed over predicted mass loss ratio of up to eight was reported for the brightest members of the R136a cluster, for which $M_i \sim 100\ M_\odot$ was found. The failure of the theory is also present when one compares observed over predicted wind momentum as a function of wind performance number. This strongly indicates that the shortcoming of the present state of the theory is connected to the neglect of effects of multiple photon momentum transfer.

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Galactic planetary nebulae with Wolf-Rayet nuclei. I. Objects with [WC]-early type stars

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Spatially resolved long-slit spectrophotometric data for the planetary nebulae PB 6, NGC 2452, NGC 2867, NGC 6905 and He 2-55 are presented. Different knots were observed in each nebula. All the nebulae are ionized by [WC 2–3] type nuclei. For the five objects, we calculated photoionization models using the ionizing radiation field from models of expanding atmospheres. The photoionization models, built with the condition that the predicted stellar visual magnitude is equal to the observed one, were rather successful in reproducing at the same time the ionization structure and the electron temperature of the nebulae, using model atmospheres that were close (±20 000 K) to the best fit for reproducing the stellar features, as presented by Koesterke & Hamann (1997a). The constraints for the modelling procedure were to reproduce the observed intensity ratios of important lines of different ionization stages, and to be roughly consistent with the observed Hβ flux, angular diameter and morphology of the nebulae. We found that, for some objects, only two-density models with an inner zone of lower density can meet all these requirements. These density structures are consistent with the morphology showed by the nebulae. In a couple of cases, our photoionization modelling seems to indicate that the models of expanding atmospheres used could be lacking ionizing photons with respect to their emission in the V band.

Chemical abundances in the nebulae were derived from the ionic abundances observed and ionization correction factors obtained from the models. We found that, while the five nebulae of our program have very similar exciting stars (similar stellar temperatures, mass loss rates, chemical compositions), the nebular chemical compositions are different. PB 6 and NGC 2452 are He-, N-, and probably C-rich nebulae, indicating massive progenitors ($M_{\rm initial} \geq 2.8 M_\odot$). In particular, abundances in PB 6 are consistent with a scenario of C produced via the triple-α process, being brought to the surface by the third dredge-up event and partially converted into N through envelope-burning. The other nebulae present typical disk-PNe abundances, showing only C enrichment (C/O $\geq$ 1). Therefore their

progenitors were not massive, but all underwent the third dredge-up. Thus, clearly, post-AGB stars of quite different initial masses can pass through a [WC] stage with similar atmospheric parameters. We did not find evidence for abundance variations inside any of the nebulae. In PB 6 and NGC 2867, we found that the C/O ratios derived from the [C III] 1909/[O III] 5007 line ratios would induce electron temperatures significantly lower than observed. The discrepancy would be larger if carbon abundances derived from the optical C II 4267 recombination lines are considered.

Accepted by by Astronomy & Astrophysics
Preprints from `miriam@astroscu.unam.mx`
or by anonymous ftp to `132.248.1.7/incoming/miriam/WRPN.ps.gz`

The variable central star of PN G 243.8−37.1

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Spectroscopic and photometric variations of the central star of the planetary nebula PRTM 1 (PN G 243.8−37.1) have been detected from optical spectrophotometric data. The photometric variations can be as large as $\delta V \sim 1$ mag, but most of the time are within 0.2 mag. The phenomenon seems to be cyclic. These optical changes confirm the *UV* variations reported by Feibelman (1998) from *IUE* archived data. The star presents a highly ionized spectrum, showing absorption lines of H 1 and He 2. The stellar features also change becoming deeper when the star is brighter, while at the same time the C 4 λ5808 doublet appears in emission. The star cannot be classified as an "O 6" star, as proposed by Feibelman (1998), because the optical O 6 lines are absent from the spectrum. The nebular lines show no sign of variation. The possible origin of the stellar changes is discussed.

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The William-Wehlau Spectropolarimeter: Observing Hot Stars in all Four Stokes Parameters

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We introduce a new polarimeter unit which, mounted at the Cassegrain focus of any telescope and

fiber-connected to a fixed CCD spectrograph, is able to measure all Stokes parameters I, Q, U and V across spectral lines of bright stellar targets and other point sources in a quasi-simultaneous manner. Applying standard reduction techniques for linearly and circularly polarized light we are able to obtain photon-noise limited line polarization. We briefly outline the technical design of the polarimeter unit and the linear algebraic Mueller calculus for obtaining polarization parameters of any point source. In addition, practical limitations of the optical elements are outlined.

We present first results obtained with our spectropolarimeter for four bright, hot-star targets: We confirm previous results for Hα in the bright Be star γ Cas and find linear depolarization features across the emission line complex C 3/C 4 (5696/5808 Å) of the WR+O binary γ^2 Vel. We also find circular line polarization in the strongly magnetic Ap star 53 Cam across its Hα absorption line. No obvious line polarization features are seen across Hα in the variable O star θ^1 Ori C above the $\sigma \sim 0.2\%$ instrumental level.

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The evolved B[e] star HD 87643 : observations and a radiation driven disk-wind model for B[e] stars

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New high resolution spectroscopic and medium resolution spectropolarimetric data, complemented with optical broad and narrow band imaging, of the B[e] star HD 87643 are presented. The spectrum of HD 87643 exhibits the hybrid characteristics well known to be representative of the group of B[e] stars; a fast wind with an expansion velocity in excess of 1000 kms^{-1} is measured in the hydrogen and helium lines, while a slower component is traced by lower excitation lines and forbidden lines. Clues to the geometry of the rapidly expanding circumstellar shell are provided by the startling polarization changes across Hα . Comparison with published schematic calculations indicates that the polarizing material is located in a slowly rotating, expanding disk structure. A hydrodynamical model is then presented whose results are consistent with the original two-wind concept for B[e] stars and exhibits kinematic properties that may well explain the observed spectral features in HD 87643. The model calculations use as input a B star undergoing mass loss, surrounded by an optically thick disk. The resulting configuration consists of a fast polar wind from the star and a slowly expanding disk wind. The model also predicts that the stellar wind at intermediate latitudes is then presented whose results are consistent with the original two-wind concept for B[e] stars and exhibits kinematic properties that may well explain the observed spectral features in HD 87643. The model calculations use as input a B star undergoing mass loss, surrounded by an optically thick disk. The resulting configuration consists of a fast polar wind from the star and a slowly expanding disk wind. The model also predicts that the stellar wind at intermediate latitudes is slower and denser than in the polar region.

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New Identifications for Blue Objects Towards the Galactic Center: post-AGB stars, Be/disk stars, and others

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As part of a programme to investigate spatial variations in the Galactic chemical composition, we have been searching for normal B-type stars and A-type supergiants near the Galactic Center. During this search we have found eleven peculiar stars, and in some cases performed detailed abundance analyses of them which suggest that they may be at a post-AGB evolutionary stage.

The A-type post-AGB candidates show [Fe/H]=−1.0 to −2.0, and [O/Fe]∼+1.4, typical of the post-AGB abundance patterns discussed in the literature. One star, LS 3591 (=SAO 243756), has also been examined recently by Oudmaijer (1996); its spectrum appears to be changing very rapidly, which may indicate erratic mass loss or the incipient formation of a planetary nebula.

A B-type post-AGB candidate, LS 4950, has a similar spectrum to a well studied post-AGB star, LSIV -12 111. However, an examination of the line strengths and elemental abundances of LS 4950 show that it is peculiar for both a Population II, post-AGB, B-type star and for a normal, Population I, B-type supergiant. Two other B-type stars, LS 4825 and LS 5112, are either post-AGB stars near the Galactic Center or normal B-type supergiants lying well beyond the Galactic Center. In addition, several Be-type stars have been newly (or more clearly) identified from our spectra.

Accepted by Astronomy & Astrophysics

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The First Ultraviolet and Optical Spectropolarimetry of the B[e] Star HD 50138

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We report the first ultraviolet spectropolarimetry of the B[e] star HD 50138, obtained with the Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE) aboard the *Astro-2* space shuttle mission in 1995 March. The data cover the spectral range 1500 - 3200Å. Spectropolarimetry obtained contemporaneously in the range of 3800 - 10000Å in the visual to near-IR region are presented as well. The presence of intrinsic polarization is detected from the UV to the near-IR. Strong evidence of a

thin gaseous disk around the star is found. An almost flat wavelength dependence of the intrinsic polarization in the optical spectral region indicates that electron scattering rather than dust scattering is the dominant polarizing mechanism, although a small contribution due to dust scattering cannot be completely ruled out. A small inclination of the disk away from edge-on with respect to the line of sight is suggested. Comparison with similar polarimetric observations obtained for different objects that have the same circumstellar geometry shows that the envelope of HD 50138 probably has a rather large density contrast between the equatorial and polar regions which does not produce a position angle flip like that observed in other objects, notably HD 45677.

To appear in The Astrophysical Journal (20 Dec 1998)
Preprints from `karen@astro.utoledo.edu`
or by anonymous ftp to `ftp.sal.wisc.edu under pub/karen/hd50138`
or on the web at `http://ardbeg.astro.utoledo.edu/ karen/biblio.html`

Submitted Papers

Massive Stars in the Quintuplet Cluster

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We present near-infrared photometry and K-band spectra of newly-identified stars in the Quintuplet Cluster, one of the three known massive clusters projected within 50 pc of the Galactic Center. We find that the cluster contains a variety of massive stars, including more unambiguously identified Wolf-Rayet stars than any other cluster in the Galaxy, and over a dozen other stars in earlier stages of evolution, i.e., LBV, Ofpe/WN9, and OBI. One newly identified star may be the second "Luminous Blue Variable" identified in the cluster, after the "Pistol Star." While we are unable to provide certain spectral classifications for the five enigmatic Quintuplet-proper stars, we tentatively propose that they are extremely dusty versions of the WC stars found elsewhere in the cluster, and similar to the dozen or so known examples in the Galaxy. Given the evolutionary stages of the identified stars, the cluster appears to be about 3.5 Myr old. The total mass is estimated to be $\sim 10^4$ $M_\odot$, and the mass density in stars is $\gtrsim$ a few thousand $M_\odot$ pc^{-3}. The newly-identified stars increase the estimated ionizing flux from this cluster by about an order of magnitude with respect to earlier estimates, to $10^{50.9}$ photons s^{-1}, or roughly what is required to ionize the nearby "Sickle" HII region (G0.18−0.04). The total luminosity from the massive cluster stars is $\approx 10^{7.5}$ L$_\odot$, enough to account for the heating of the nearby molecular cloud, M0.20−0.033. We propose a picture which integrates most of the major features in this part of the sky, excepting the non-thermal filaments. We compare the cluster to other young massive clusters and globular clusters, finding that it is unique in stellar content and age, except, perhaps, for the young cluster in the central parsec of the Galaxy. In addition, we find that the cluster is comparable to small "super star clusters."

Submitted to the Astrophysical Journal
or on the web at `http://www.astro.ucla.edu/ figer/papers.html`

Microlensing of Circumstellar Envelopes I. Simplified considerations for diagnosing radial and azimuthal flow

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This paper presents first results on the line profile shapes from a circumstellar envelope in bulk motion as modified by a microlensing event. Only geometrically and optically thin spherical shells in uniform expansion or rotation are considered here so as to emphasise the information content available in the profile shapes. In particular it is demonstrated that for the case of expansion, the line emission can increase by significant factors and the time variation of the profile shape is *symmetric* about line centre. For uniform rotation the line emission also increases significantly, but the time evolution of the profile shape is distinctly *asymmetric*. Thus, microlensing is seen to yield information about the velocity field in the extended envelope. We elaborate on (a) the observational advantages of tailoring microlensing programs toward detecting extended circumstellar envelopes, (b) the use of multiline observations to infer other properties of the envelopes, such as the ionization stratification, (c) the use of the continuum excess emission at infrared wavelengths as a means of probing the envelope structure, and (d) the use of polarisation for constraining the properties of "clumpy" winds.

Submitted to Astronomy and Astrophysics *For preprints, contact* `rico@astro.gla.ac.uk`
Preprints available from anonymous ftp-server - info.astro.gla.ac.uk /pub/rico/microlens.ps

In Proceedings

Superbubbles in the Magellanic Clouds

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Superbubbles that result from the stellar winds and supernovae of OB associations probably play a fundamental role in the structure and energetics of the ISM in star-forming galaxies. Their influence may also dominate the relationship between the different interstellar gas phases. How do superbubbles form and evolve? How do they affect the local and global ISM? The Magellanic Clouds provide a superior opportunity to study this shell-forming activity, since both stellar content and gaseous structure can be examined in detail. Here, the results of recent studies of superbubbles in the Magellanic Clouds are reviewed.

Review paper to appear in *New Views of the Magellanic Clouds*, **IAU Symp. 190 (July 12-17, 1998), eds. Y.-H. Chu, N. Suntzeff, J. Hesser, & D. Bohlender.**
Preprints from `oey@ast.cam.ac.uk`
or on the web at `http://www.ast.cam.ac.uk/~oey/oeypubs.html`
and `http://xxx.lanl.gov/abs/astro-ph/9807271` and mirrors.

HST NICMOS Observations of Circumstellar Matter Around Cyg X-3

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Models of the evolution of massive binaries predict that only a few such objects should survive the common envelope phase and result in systems containing a compact object plus a Wolf-Rayet star (c+WR). According to these models, a vast amount of stellar material is lost during the common envelope phase prior to the c+WR phase. We are attempting to test these models by searching for the presence of such circumbinary material around the only known c+WR object: Cyg X-3. Since the large reddening towards Cyg X-3 prevents any investigation in the optical, deep infrared exposures of Cyg X-3 with the NICMOS NIC-2 camera aboard HST and the Paα narrow band filter have been used to image the system at high spatial resolution.

The HST images have only recently been acquired and their analysis is currently underway. Here we report the possible detection of emission at a distance of about $0\farcs3$. This result is preliminary and needs confirmation by NIC-1 observations with its better sampling of the stellar profile.

To appear in: NICMOS and the VLT: A New Era of High Resolution Near Infrared Imaging and Spectroscopy, eds. W. Freudling et al., ESO CWP, in press
Preprints from `schmutz@astro.phys.ethz.ch`
or by anonymous ftp to `saturn.ethz.ch: pub/astro2/schmutz/nicmos_cygx3.ps.Z`

Book

The Brightest Binaries

D. Vanbeveren, W. Van Rensbergen, and C. De Loore

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The monograph describes in extenso the present state of massive star research seen from the standpoint of stellar evolution, with special emphasis on close binaries. Statistics of massive close binaries are reasonably complete for the Solar neighbourhood. We demonstrate that within our knowledge, many scientific results where the effect of binaries are ignored, have an academic value but may be far from reality.

In chapter I, we summarize general observations of massive stars where we focus on the HR diagram, stellar wind mass loss rates, the stellar surface chemistry, rotation, circumstellar environments, supernovae.

Close binaries can not be studied separately from single stars and vice versa. First, the evolution of single stars is discussed (chapter II). We present new calculations with updated stellar wind mass loss rate formalisms. Especially the rates during the red supergiant phase and the rates during the

Wolf-Rayet (WR) phase are different compared to previous values and this affects in a profound way the evolution during core helium burning. The computations are compared in detail to representative observations. The chapter ends with a general discussion on the effects of rotation on massive single star evolution.

Massive binaries, the main topic of the work, are considered in chapter III. Basic processes are described, i.e. the Roche lobe overflow and mass transfer, the common envelope process, the spiral-in process in binaries with extreme mass ratio, the mass accretion process and the merging process, the effect of the (asymmetric) supernova explosion of one of the components on the orbital parameters of the binary. Evolutionary computations of interacting close binaries are discussed and general conclusions are drawn. The enormous amount of observational data of massive binaries is summarized. We separately consider the non-evolved and evolved systems. The latter class includes the semi-detached and contact binaries, the WR binaries, the X-ray binaries, the runaways, the single and binary pulsars. A general comparison between theoretical evolution and observations is combined with a discussion of specially interesting binaries: the evolved binaries HD 163181, HD 12323, HD 14633, HD 193516, HD 25638, HD 209481, ϕ Per and υ Sgr; the WR+OB binaries γ^2Vel, V444 Cyg; the high mass X-ray binaries Vela X-1, Wray 977, Cyg X-1; the low mass X-ray binaries Her X-1 and those with a black hole candidate; the runaways ζ Oph and ζ Pup, the WR+compact companion candidates HD 50896 and Cyg X-3; the supernova event SN 1987A. We finally propose an overall evolutionary model of massive close binaries as a function of primary mass, mass ratio and orbital period.

The fourth chapter deals with massive star population synthesis with a realistic population of binaries. We discuss the massive close binary frequency, mass ratio and period distribution, the observations that allow to constrain possible asymmetries during the supernova explosion of a massive star. Observed star numbers (as a function of metallicity) are then compared to theoretically predicted numbers where we focus on stellar populations in regions of continuous star formation and in starburst regions. Special attention is given to the O-type star/WR star/red supergiant star population, the pulsar and binary pulsar population, the supernova rates.

The monograph counts 347 pages, contains a considerable amount of new results and will be useful as reference work for everybody working in the field of massive stars in general, in the field of massive binaries in particular. Our hope is that this book encourages youngish researchers to pursue binary research, rather than fall into the bottomless pit of extra-Galactic research, including the eternal and largely illusory quest for 'standard candles'. Probably the best standard candles are, or will be, massive OB eclipsing systems, which in principle are capable of giving distances independent of the usual chain of hypotheses.

The book is published by Kluwer (Dordrecht), ISBN 0-7923-5155-X and can be ordered on-line via www.wkap.nl.

Meetings

One-day Discussion on the Enigmatic SMC System HD 5980

Monday Nov. 2, 1998, Puerto Vallarta, Mexico

Organizer: Tony Moffat
moffat@astro.umontreal.ca

Tony suggests the following topics. Please send him comments/suggestions and indicate where *you* wish to be involved, before 31 Aug 1998.

0. Overview
1. What is the nature of the stars before the eruption in 1994?
   – what is the true orbit?
   – is it a triple system?
   – what are the masses?
   – are there orbit-induced oscillations?
   – anomalous phase-dependent behaviour of the spectral lines:
   wind-wind collision vs. atmospheric eclipses vs. heating effects vs. 2 WR stars
   – how does HD 5980 fit in with the evolution of its parent cluster NGC 346?
2. What really happened during the eruption?
   – which star erupted?
   – why only to WN11, like AG Car at minimum?
   – what is the total mass ejected during the eruption?
3. What is happening now and what will happen next?
4. Who is doing what presently?
5. Coordinated future campaigns?

Afternoon Discussion on the XMEGA Campaign

Monday Nov. 2, 1998, Puerto Vallarta, Mexico

Organizer: Mike Corcoran
corcoran@barnegat.gsfc.nasa.gov

IAU Colloquium No. 175
The Be Phenomenon in Early-Type Stars

28 June– 2 July, 1999, Alicante, Spain

SOC: Balona, L. (South Africa), Bjorkman, J. (United States), Fabregat, J. (Spain), Fullerton, A. (Canada), Hummel, W. (Germany), Kambe, E. (Japan), Marlborough, M. (Canada), Mennickent, R. (Chile), Roche, P. (United Kingdom), Smith, M. (United States, Chair), Stefl, S. (Czech Republic), Wang, Z. (China)

A preliminary program and logistic information can be obtained from Myron Smith
`MSMITH@nebula.gsfc.nasa.gov`
or on the Web at the URL of the B Star Newsletter:
`http://www.chara.gsu.news/BeNews/iaucoll175.html`