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The projected meeting on Massive Star Birth, announced in the previous issue of this newsletter, is planned for 2004, not 2002. Apologies from the editor for that mistake.

P CYGNI 2000: 400 Years of Progress

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A limited number of copies of the Proceedings of the International Workshop "P Cygni 2000: 400 years of progress", held in Armagh, 21-23 August 2000, is now for sale at the reduced price of USD 25.00 per copy. Orders can be placed with Mart de Groot at "mdg@star.arm.ac.uk". In the text give your credit card number, date of expiry, the name on the card, and mention that you are willing to pay the price of USD 25.00 per copy ordered. We also need your correct postal address. You will be debited with USD 25.00 and the book will be sent to you by airmail. An overview of the contents of these Proceedings can be found on the Workshop's web page at www.arm.ac.uk/∼mdg.

Accepted Papers

The Spectral Energy Distribution and Mass-loss Rate of the A-Type Supergiant Deneb

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A stellar wind module has been developed for the `PHOENIX` stellar atmosphere code for the purpose of computing non-LTE, line-blanketed, expanding atmospheric structures and detailed synthetic spectra of hot luminous stars with winds. We apply the code to observations of Deneb, for which we report the first positive detections of mm and cm emission (obtained using the SCUBA and the VLA), as well a strong upper limit on the 850μm flux (using the HHT). The slope of the radio spectrum shows that the stellar wind is partially ionized. We report a uniform-disk angular diameter measurement, $\overline{\theta_{\rm UD}} = 2.40 \pm 0.06$ mas, from the Navy Prototype Optical Interferometer (NPOI). The measured bolometric flux and corrected NPOI angular diameter yield an effective temperature of 8600 ± 500 K. Least-squares comparisons of synthetic spectral energy distributions from 1220 Å to 3.6 cm with the observations provide estimates for the effective temperature and the mass-loss rate of $\simeq 8400 \pm 100$ K and $8 \pm 3 \times 10^{-7}$ $M_\odot$ yr^{-1}, respectively. This range of mass-loss rates is consistent with that derived from high dispersion UV spectra when non-LTE metal-line blanketing is considered. We are unable achieve a reasonable fit to a typical Hα P-Cygni profile with any model parameters over a reasonable range. This is troubling because the Hα profile is the observational basis for Wind Momentum-Luminosity Relationship.

Accepted by The Astrophysical Journal

Preprints from `jaufdenberg@cfa.harvard.edu`
or on the web at `http://cfa-www.harvard.edu/~jaufdenb/deneb`

BeppoSAX broad X-ray range observations of η Car during high and low spectroscopic states

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We present BeppoSAX spectra of the extremely luminous and massive object η Car observed in a very broad X–ray range (0.1–200 keV) during high state (December 1996) and egress from the last low state (March 1998). Both spectra are composed of at least two components, a soft one with $kT_s <$ 0.7 keV, and a hard with kT_h=4.7 keV. We found in March 1998 a large flux defect in the 1.5–4 keV range, while the flux remained constant below 1.5 keV and above 5 keV. We attribute this defect to a $\times$3.5 increase of the absorbing matter in front of the hard component, while its temperature and unabsorbed luminosity were nearly the same in the two epochs. In December 1996 the PDS X–ray flux in the 13–20 keV range is larger than the extrapolated hard spectrum, indicating the presence of an even harder additional component, which possibly declined during the March 1998 low state. Conversely, we find that at that time, the flux of the 6.7 keV iron line was 40% stronger. Coordinated optical and NIR spectroscopic observations indicate that in March 1998 η Car was still in a state of low excitation of the emission line spectrum, with extended P Cygni absorptions. These results indicate that after the X–ray flux minimum, the hard component recovered its high state luminosity more rapidly than the high ionization spectral lines, but in the meantime it was partly occulted by a large amount of absorbing matter placed in front of the source. These results are discussed in the framework of the proposed binary model of η Car.

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A New Spectral Classification System for the Earliest O Stars: Definition of Type O2

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High-quality, blue-violet spectroscopic data are collected for 24 stars that have been classified as type O3 and that display the hallmark N IV and N V lines. A new member of the class is presented; it is the second known in the Cygnus OB2 association, and only the second in the Northern Hemisphere. New digital data are also presented for several of the other stars. Although the data are inhomogeneous, the uniform plots by subcategory reveal some interesting new relationships. Several issues concerning the classification of the hottest O-type spectra are discussed, and new digital data are presented for

the five original O3 dwarfs in the Carina Nebula, in which the N IV, N V features are very weak or absent. New spectral types O2 and O3.5 are introduced here as steps toward resolving these issues. The relationship between the derived absolute visual magnitudes and the spectroscopic luminosity classes of the O2-O3 stars shows more scatter than at later O types, at least partly because some overluminous dwarfs are unresolved multiple systems, and some close binary systems of relatively low luminosity and mass emulate O3 supergiant spectra. However, it also appears that the behavior of He II λ4686, the primary luminosity criterion at later O types, responds to other phenomena in addition to luminosity at spectral types O2-O3. There is evidence that these spectral types may correspond to an immediate pre-WN phase, with a correspondingly large range of luminosities and masses. A complete census of spectra classified into the original O3 subcategories considered here (not including intermediate O3/WN types or O3 dwarfs without N IV, N V features) totals 45 stars; 34 of them belong to the Large Magellanic Cloud and 20 of the latter to 30 Doradus.

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An analysis of STIS HST UV spectra of M33 early B supergiants

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We present terminal velocities of M33 B-supergiants, obtained from STIS HST spectra as part of our programme to investigate the Wind Momentum - Luminosity Relationship (WLR) in the Local Group. Terminal velocities are derived from their N V, CIV and Si IV resonance lines in UV spectra. Comparing with IUE spectra of Galactic B-supergiants we found evidence of low metallicity in three of our objects. The terminal velocities are consistent with the corresponding values of Galactic stars, except for B-133. For this star we find a very large v_∞ and a red Si IV component deeper than the blues one, that might be an indication of binarity. The average ratio between terminal and turbulent wind velocities is 0.25, well above the value found for Galactic stars.

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Spectral variability of luminous early type stars.II. Supergiant α Cam

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Time-series of Hα spectra with relatively high resolution in wavelength (R = $\lambda/\delta\lambda$ of 15 000 to 22 000) and time (Δt =1$^{\rm d}$) of the late-type O supergiant α Cam are analysed in terms of line-profile variability (lpv). The spectra cover an interval of one year, from February 1998 to February 1999. The analysis provides clear evidence of a continuous deep seated wind activity traced by variations in the Hα emission and He I λ6678.15 absorption lines. The observations indicate that the wind is not smooth but perturbed starting from its base up to velocities of $\sim$500 km s^{-1}. The character of the medium-term (days) variations found in Hα changes between epochs, and appears to require explanation involving different kinds of wind perturbations. In particular, we found that in June and July, 1998 as well as in February, 1999 the lpv of Hα was dominated by low-amplitude ($\leq \pm$10%) variations in line flux which usually occupy the central part of the profile symmetrically with respect to the line center while in December, 1998 and January, 1999 the variations were organised in two wave-like modulations that run from "red" to "blue" and back to "red" within the profile (between $\pm$300 km s^{-1}) being most of the time in antiphase. The timescale of variation, revealed via Fourier analysis, is respectively $\sim$7 and $\sim$10 days. Significant variations in emission equivalent width (up to 35%), closely linked to those in the line profile, are also noted. Short-term (3 to 4 days), low-amplitude ($\leq$22%) variation in mass loss rate which recurs on a timescale of $\sim$7 days giving rise to the formation of outward accelerating consecutive shells or/and blobs was suggested to explain the lpv of Hα in June–July, 1998 and in February, 1999. Whereas the variability pattern observed in December – January, 1999 seems to be qualitatively consistent with a model involving two rotationally modulated wind perturbations, one of enhanced density and another of reduced density with respect to the mean, which are not symmetric about the center of the star. Strange-mode oscillations or radial fundamental pulsation are discussed as possible mechanisms generating the established wind variability.

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Multicomponent radiatively driven stellar winds III. Radiative-acoustic waves in a two-component wind

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We study stability of isothermal two-component radiatively driven stellar winds against one-dimensional perturbations larger than the Sobolev length, and radiative-acoustic waves in such stellar winds. We perform linear perturbation analysis in comoving fluid-frames of individual components and obtain dispersion relation in the common fluid-frame. For high density winds the velocity difference between velocities of both components is relatively small and the wind is stable for radiative-acoustic waves discovered originally by Abbott, in accordance with the previous studies of the one-component wind. However, for such high density winds we found new types of waves including a special case of

"frozen-in" wavy patterns. On the other hand, if the velocity difference between wind components is sufficiently large (for low density winds) then the multicomponent stellar wind is unstable even for large scale perturbations and ion runaway occurs. Thus, isothermal two-component stationary solutions of the radiatively line driven stellar wind with an abrupt lowering of the velocity gradient are unstable.

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Light variations of massive stars (α Cyg variables). XVIII. The B[e] supergiants S 18 in the SMC and R 66 = HDE 268835 and R 126 = HD 37974 in the LMC

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We discuss photometric monitoring ($VBLUW$ system) of three B[e] supergiants. All three objects appear to be variable. They are subject to two (R 66 and R 126 in the LMC) and three (S 18 in the SMC) types of light oscillations which range from a few days to years, and are probably due to pulsations. We argue that a classification as α Cyg variables is justified. Their classification as mixed B[e]/S Dor variables is less certain, though not impossible at all. Also based on other cases, a strong B[e]–S Dor variable connection seems to be present.

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The ever challenging emission-line binary β Lyræ

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A brief history of investigations of β Lyr, an emission-line binary and one of the first ever discovered Be stars is presented. A rather fast progress in the understanding of this enigmatic object during the past fifteen years is then discussed in some detail. The current picture of β Lyr is that it is an eclipsing binary in a stage of mass transfer between the components. The mass-losing star is a B6-8II object, with a mass of about 3 $M_\odot$, which is filling the Roche lobe and sending material towards its more massive companion at a rate of about 2×10^{-5} $M_\odot\,yr^{-1}$. This leads to the observed rapid increase of the orbital period at a rate of 19 s per year. The mass-gaining star is as early B star with a mass of about 13 $M_\odot$. It is completely hidden inside an opaque accretion disk, jet-like structures, perpendicular to the orbital plane and a light-scattering halo above the poles of the star. The observed radiation of the disk corresponds to an effective temperature which is much lower than what would correspond to an early B star. The disk shields the radiation of the central star in the directions along the orbital plane and redistributes it in the directions perpendicular to it. That is why the mass-losing star appears brighter of the two in the optical region of the spectrum. At present, rather

reliable estimates of all basic properties of the binary and its components are available. However, in spite of great progress in understanding the system in recent years, some disagreement between the existing models and observed phase variations still remains, both for continuum and line spectrum, which deserves further effort.

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Properties and nature of Be stars. 21. The long-term and the orbital variations of V832 Cyg = 59 Cyg

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An analysis of numerous homogenized UBV photoelectric observations and red spectra of the Be star V832 Cyg from several observatories led to the following principal findings:
1. Pronounced long-term light and colour variations of V832 Cyg result from a combination of two effects: from the gradual formation of a new Be envelope, and from an asymmetry and a slow revolution of the envelope (or its one-armed oscillation). The colour variations associated with the envelope formation are characterized by a positive correlation between brightness and emission strength, typical for stars which *are not* seen roughly equator-on.
2. The V magnitude observations prewhitened for the long-term changes follow a sinusoidal orbital light curve with a small amplitude and a period of $28\overset{\mathrm{d}}{.}1971$ which is derived from observations spanning 43 years. This independently confirms a 12-year old suggestion that the star is a spectroscopic binary with a 29-d period. V832 Cyg thus becomes the fifth known Be star with cyclic long-term V/R variations, the duplicity of which has been proven, the four other cases being ζ Tau, V923 Aql, γ Cas and X Per. Therefore, the hypothesis that the long-term V/R variations may arise due to the attractive force of the binary companion at certain phases of the envelope formation is still worth considering as a viable alternative to the model of one-armed oscillation.
3. We have shown that the RV and V/R variations of the Hα and He I 6678 emission lines are all roughly in phase. In particular, the He I 6678 emission also moves with the Be primary which differs from what was found for another Be binary, φ Per.
4. We derived the orbital elements and found that in spite of the remaining uncertainties, the basic physical properties of the $28\overset{\mathrm{d}}{.}2$ binary are well constrained.

5. The light minimum of the orbital light curve occurs at elongation when the Be star is approaching us and the object becomes bluest in $(B-V)$ and reddest in $(U-B)$ at the same time. This may indicate that a part of the optically thick regions of the envelope is eclipsed at these orbital phases.

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XMM-Newton Detection of Hard X-ray Emission in the Nitrogen-type Wolf-Rayet Star WR 110

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We have used the excellent sensitivity of XMM-Newton to obtain the first high-quality X-ray spectrum of a Wolf-Rayet (WR) star which is not known to be a member of a binary system. Our target, the nitrogen-type star WR 110 (= HD 165688) was also observed and detected with the VLA at four different frequencies. The radio flux density increases with frequency according to a power law $S_\nu \propto \nu^{+0.64\pm0.10}$, in very good agreement with the behavior expected for free-free wind emission. The radio data give an ionized mass-loss rate $\dot{M} = 4.9 \times 10^{-5}$ $M_\odot$ yr^{-1} for an assumed spherical constant-velocity wind.

The undispersed CCD X-ray spectra reveal strong emission lines from He-like ions of Mg, Si and S. The emission measure distribution shows a dominant contribution from cool plasma with a characteristic temperature $kT_{cool} \approx 0.5$ keV (≈6 MK). Little or no excess absorption of this cool component above the value expected from the visual extinction is present. We conclude that the bulk of the cool plasma detected by XMM-Newton lies at hundreds of stellar radii or more if the wind is approximately spherical and homogeneous, but it could lie closer to the star if the wind is clumped. If the cool plasma is due to instability-driven wind shocks then typical shock velocities are $v_s \approx 340$ - 550 km s^{-1} and the average filling factor of X-ray emitting gas in the wind is no larger than $f \sim 10^{-6}$.

A surprising result is the unambiguous detection of a hard X-ray component which is clearly seen in the hard-band images and the spectra. This hard component accounts for about half of the observed flux and can be acceptably fitted by a hot optically thin thermal plasma or a power-law model. If the emission is thermal, then a temperature $kT_{hot} \geq 3$ keV is derived. Such high temperatures are not predicted by current instability-driven wind shock models and a different mechanism is thus required to explain the hard X-rays. We examine several possible mechanisms and show that the hard emission could be accounted for by the WR wind shocking onto a close stellar companion which has so far escaped detection. However, until persuasive evidence for binarity is found we are left with the intriguing possibility that the hard X-ray emission is produced entirely by the Wolf-Rayet star.

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Mass-Loss Rate Determination for the Massive Binary V444 Cyg using 3-D Monte-Carlo Simulations of Line and Polarization Variability

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A newly developed 3-D Monte Carlo model is used, in conjunction with a multi-line non-LTE radiative transfer model, to determine the mass-loss rate of the Wolf-Rayet (W-R) star in the massive binary V444 Cyg (WN5+O6). This independent estimate of mass-loss rate is attained by fitting the observed He I 5876 Å and He II 5412 Å line profiles, and the continuum light curves of three Stokes parameters (I, Q, U) in the V band simultaneously. The high accuracy of our determination arises from the use of many observational constraints, and the sensitivity of the continuum polarization to the mass-loss rate. Our best fit model suggests that the mass-loss rate of the system is $\dot{M}_{\rm WR} = 0.6\,(\pm 0.2) \times 10^{-5}\,M_{\odot}\,{\rm yr}^{-1}$, and is independent of the assumed distance to V444 Cyg. The fits did not allow a unique value for the radius of the W-R star to be derived. The range of the volume filling factor for the W-R star atmosphere is estimated to be in the range of 0.050 (for $R_{\rm WR} = 5.0\,R_{\odot}$) to 0.075 (for $R_{\rm WR} = 2.5\,R_{\odot}$). We also found that the blue-side of He I 5876 Å and He II 5412 Å lines at phase 0.8 is relatively unaffected by the emission from the wind-wind interaction zone and the absorption by the O-star atmosphere; hence, the profiles at this phase are suitable for spectral line fittings using a spherical radiative transfer model.

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Kinematical structure of Wolf-Rayet winds. I. Terminal wind velocity

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New terminal wind velocities for 164 Wolf-Rayet stars (from the Galaxy and LMC) based on the P Cygni profile of1550 C IV resonance line were derived from the archive high and low resolution IUE spectra available form the INES database. The high resolution data on 59 WR stars (39 from the Galaxy and 20 from LMC, Tables 1 and 2) were used to calibrate the empirical relation (λ_{min}^{Abs} -λ_{peak}^{Emis}) vs. terminal wind velocity, which was then used for determinations of the terminal wind velocities from the low resolution IUE data. We almost doubled the previous most extended sample of such measurements (Rochowicz and Niedzielski 1995). Our new measurements, based on high resolution data, are precise within 5-7%. Measurements, based on the low resolution spectra suffer formal errors of ∼40-60%. A comparison of the present results with other determinations suggest higher precision of ∼20%. We found terminal wind velocities for the Galactic WC and WN stars correlating with the WR spectral subtype. We also found that the LMC WN stars have winds slower than their Galactic counterparts, up to two times in the case of the WNE stars. No influence of binarity on terminal wind velocities was found. Our extended set of measurements allowed us to test applicability of the radiation driven wind theory to the WR stars. We found that, contrary to OB stars, terminal wind velocities of the WR stars correlate only weakly with stellar temperature. We also note that the terminal to escape

velocity ratio for the WR stars is relatively low: 2.55±1.14 for the galactic WN stars and 1.78±0.70 for the galactic WCs. This ratio decreases with temperature of WR stars,contrary to what is observed in the case of the OB stars. The presented results show complex influence of chemical composition on the WR winds driving mechanism efficiency. Our kinematical data on WR winds suggest evolutionary sequence:WNL→WNE→WCE→WCL.

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Far Ultraviolet Spectroscopic Explorer Atlas of OB Stars in the Magellanic Clouds

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An atlas of the 900–1200 Å region in the spectra of 47 OB stars in the Large and Small Magellanic Clouds, observed at high resolution by the *Far Ultraviolet Spectroscopic Explorer*, is presented and discussed. The systematic trends in the numerous stellar-wind features in this region, some from species (and ionizations) not represented at longer wavelengths, are charted as a function of the optical spectral types. The *FUSE* sample is by far the most powerful to date for that purpose. A special effort has been made to verify the spectral types of all stars included in the atlas, in a number of cases with new optical observations that are also illustrated, to avoid uncertainties from that source in the stellar-wind trends. A new O2 star has been found in the process. Most of these stars have been previously observed at longer ultraviolet wavelengths by the *Hubble Space Telescope*, and in the optical from the ground with high-resolution, digital instruments; thus very comprehensive physical modeling of these OB atmospheres and winds now becomes possible. This atlas will serve as a guide to the *FUSE* Magellanic Cloud OB database for that purpose. The Magellanic Cloud sample provides a very important complement to the *FUSE* database of Galactic OB counterparts (Pellerin et al. 2002), both because the lower extinction and interstellar H_2 absorption toward the Cloud stars allow a much clearer view of the stellar spectra below 1100 Å, and because of the metallicity differences among the three galaxies. In particular, most wind features in the SMC spectra are seen to be significantly weaker than those in the LMC, at the same spectral types.

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The Massive Wolf-Rayet Binary SMC WR7

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We present a study of optical spectra of the Wolf–Rayet star AzV 336a (= SMC WR7) in the Small Magellanic Cloud. Our study is based on data obtained at several Observatories between 1988 and 2001. We find SMC WR7 to be a double lined WN+O6 spectroscopic binary with an orbital period of 19.56 days. The radial velocities of the He absorption lines of the O6 component and the strong HeII emission at λ4686Å of the WN component describe antiphased orbital motions. However, they show a small phase shift of $\sim$ 1 day. We discuss possible explanations for this phase shift. The amplitude of the radial velocity variations of He II emission is twice that of the absorption lines. The binary components have fairly high minimum masses, $\sim$ 18 $M_\odot$ yr^{-1}and 34 $M_\odot$ yr^{-1}for the WN and O6 components, respectively.

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Tomographic Separation of Composite Spectra. X. The Massive Close Binary HD 101131

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We present the first orbital elements for the massive close binary, HD 101131, one of the brightest objects in the young, open cluster, IC 2944. This system is a double-lined spectroscopic binary in an elliptical orbit with a period of 10.15952 ± 0.00014 days. It is a young system of unevolved stars (approximately 2 million years old) that are well within their critical Roche surfaces. We use a Doppler tomography algorithm to reconstruct the individual component optical spectra, and we apply well known criteria to arrive at classifications of O6.5 V((f)) and O8.5 V for the primary and secondary, respectively. We compare the reconstructed spectra of the components to single star, spectrum standards to determine a flux ratio of $f_2/f_1 = 0.52 \pm 0.08$ in the V-band. Both components are rotating faster than synchronously. We estimate the temperatures and luminosities of the components from the observed spectral classifications, composite V magnitude, and cluster distance modulus. The lower limits on the masses derived from the orbital elements and the lack of eclipses are $27M_\odot$ and $16M_\odot$ for the primary and secondary, respectively. These limits are consistent with the somewhat larger masses estimated from the positions of the stars in the Hertzsprung-Russell diagram and evolutionary tracks for single stars.

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Wind Accretion and Binary Evolution of the Microquasar LS 5039

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There is much evidence to suggest that stellar wind capture, rather than Roche lobe overflow, serves as the accretion mechanism onto the compact secondary object in the massive X-ray binary LS 5039. The lack of significant emission combined with only a modest X-ray flux provide observational evidence that no large-scale mass transfer is occurring (consistent with our estimate of the radius of the O6.5 V((f)) optical star that is smaller than its critical Roche radius). Here we determine the mass loss rate of the optical star from the broad, residual emission in the Hα profile. Using a stellar wind accretion model for a range in assumed primary mass, we compute the predicted X-ray luminosity for the system. We compare our results to the observed X-ray luminosity to determine the mass of the compact object for each case. The companion appears to be a neutron star with a mass between 1 and $3M_{\odot}$. With our new constraints on the masses of both components, we discuss their implications on the evolution of the system before and after the supernova event that created the compact companion. The binary experienced significant mass loss during the supernova, and we find that the predictions for the resulting runaway velocity agree well with the observed peculiar space velocity. LS 5039 may be the fastest runaway object among known massive X-ray binaries.

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Wind variability of B supergiants

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We present the most suitable data sets available in the *International Ultraviolet Explorer* (*IUE*) archive for the study of time-dependent stellar winds in early B supergiants. The UV line profile variability in 11 B0 to B3 stars is analysed, compared and discussed, based on 16 separate data sets comprising over 600 homogeneously reduced high-resolution spectrograms. The targets include 'normal' stars with moderate rotation rates and examples of rapid rotators. A gallery of grey-scale images (dynamic spectra) is presented, which demonstrates the richness and range of wind variability and highlights different structures in the winds of these stars. This work emphasises the suitability of B supergiants for wind studies, under-pinned by the fact that they exhibit unsaturated wind lines for a wide range of ionization.

The wind activity of B supergiants is substantial and has highly varied characteristics. The variability evident in individual stars is classified and described in terms of discrete absorption components, spontaneous absorption, bowed structures, recurrence, and ionization variability and stratification. Similar structures can occur in stars of different fundamental parameters, but also different structures may occur in the same star at a given epoch. We discuss the physical phenomena that may be associated with the spectral signatures. The diversity of wind patterns evident likely reflects the role

of stellar rotation and viewing angle in determining the observational characteristics of azimuthally extended structure rooted at the stellar surface.
In addition, SEI line-synthesis modelling of the UV wind lines is used to provide further information about the state of the winds in our program stars. Typically the range, implied by the line profile variability, in the product of mass-loss rate and ion fraction ($M_\odot$ yr^{-1} q_i) is a factor of ~ 1.5, when integrated between 0.2 and 0.9 v_∞; it can however be several times larger over localised velocity regions. At a given effective temperature the mean relative ion ratios can differ by a factor of 5. The general excess in predicted (forward-scattered) emission in the low velocity regime is discussed in terms of structured outflows. Mean ion fractions are estimated over the B0 to B1 spectral classes, and trends in the ionic ratios as a function of wind velocity are described. The low values obtained for the ion fractions of UV resonance lines may reflect the role of clumping in the wind.

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The effect of binarity and metallicity in the spectra of WC and WO stars

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A statistical analysis of the width and equivalent width (W_λ) of the main emission lines common to the WC and WO stars is made, based on an extensive set of spectral data. Up–to–date spectral types and binarity information has been used from Van der Hucht (2001) and Breysacher et al. (1999). To define the trends in W_λ, equivalent width ratios, and line widths over the WC and WO classes, we derive *median values* of these parameters for galactic and non–galactic single–spectrum stars of different spectral class. The most noticeable features are: (1) substantially smaller W_λ(C IV 581 nm) values for galactic WO and WC4 stars, compared to non–galactic objects; (2) smoothly increasing values of W_λ(O V 559 nm) towards early WC and WO stars, galactic as well as non-galactic; (3) a decrease in W_λ for the 465 nm blend at early WC and WO for both the galactic and non–galactic stars; (4) a marked increase in C IV 581 nm and O V 559 nm line widths for the galactic WO stars. The observed differences between galactic and non–galactic WCE/WO stars suggest environmental influences; it is argued that differences in stellar wind structure, in combination with the ambient metallicity, may be the cause of the anomalies. Variation of the 465 nm blend profiles indicates a substantial contribution of the He II 468 nm for the WCE and WO stars. A few comments are added on WC and WO carbon abundances in relation to the evolutionary status of these objects. We also give an estimate of the OB/WR continuum flux ratio in composite–spectrum systems.

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The magnetic field and wind confinement of θ^1 Orionis C

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We report the detection, through spectropolarimetric observations, of a strong dipolar magnetic field of presumably fossil origin at the surface of the very young O star θ_1 Ori C. The Stokes V signatures we detect are variable with time, the variations being consistent with rotational modulation. A detailed modelling of our observations indicate that this dipole field has an intensity of 1.1 ± 0.1 kG and is inclined at $42 \pm 6°$ with respect to the rotation axis (assumed to be inclined at 45° to the line of sight). We find in particular that the positive magnetic pole comes closest to the observer when the variable Hα emission component observed on this star reaches maximum strength. This discovery represents the first definite detection of a magnetic field in an O star, as well as the first detection of a fossil field in a very young star.

We also investigate in this paper the magnetic confinement of the radiatively driven wind of θ_1 Ori C in the context of the Magnetically Confined Wind Shock model of Babel & Montmerle (1997a). In the case of θ_1 Ori C, this model predicts the formation of a large magnetosphere (extending as far as 2 to 3 R_*), consisting of a very hot postshock region (with temperatures in excess of 10 MK and densities of about 10^{11} cm^{-3}) generated by the strong collision of the wind streams from both stellar magnetic hemispheres, as well as a dense cooling disc forming in the magnetospheric equator. We find that this model includes most of the physics required to obtain a satisfactory level of agreement with the extensive data sets available for θ_1 Ori C in the literature (and in particular with the recent X-ray data and the phase-resolved spectroscopic observations of UV and optical wind lines) provided that the mass-loss rate of θ_1 Ori C is at least 5 times smaller than that predicted by radiatively driven wind models. We finally show how new observations with the XMM or Chandra spacecrafts could help us constrain this model much more tightly and thus obtain a clear picture of how magnetic fields can influence the winds of hot stars.

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FUSE Observations Towards the Pole-On Be Star HR 5223

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New spectra have been obtained for the pole-on Be star HR 5223 (HD 120991) using the Far Ultraviolet Satellite Explorer (FUSE). We give a complete description of the far-UV spectral range (920 to 1180 Å). The spectra are affected by strong blends with interstellar lines and molecular bands that also significantly lower the energy distribution of the star. We produce a synthetic spectrum of the interstellar medium (ISM) to determine the column densities of several elements (H_2, H I, N I , O I ...) seen towards HR 5223 and to disentangle the components due to the ISM, the photosphere and/or to the circumstellar envelope. The line identification list is available at the CDS. Using the obtained column densities, we determine the reddening of the star due to the ISM only and locate the star relative to the nearby IS clouds. The fit of the dereddened UV flux distribution with models that account for the gravitational darkening due to the stellar fast rotation allowed us to estimate the stellar fundamental parameters ($T_{\rm eff}$ = 22000 K; log g = 3.7) and its distance (d = 834±20 pc). The distance obtained, which has to be considered as the most accurate available at the moment, is in agreement with the characteristics of the ISM matter distribution that affects the observed spectrum of the star and with the detecting limits of the HIPPARCOS satellite.

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Submitted Papers

Dynamical Simulations of Magnetically Channeled Line-Driven Stellar Winds: I. Isothermal, Nonrotating, Radially Driven Flow

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We present numerical magnetohydrodynamic (MHD) simulations of the effect of stellar dipole magnetic fields on line-driven wind outflows from hot, luminous stars. Unlike previous fixed-field analyses, the simulations here take full account of the dynamical competition between field and flow, and thus apply to a full range of magnetic field strength, and within both closed and open magnetic topologies. A key result is that the overall degree to which the wind is influenced by the field depends largely on a single, dimensionless, 'wind magnetic confinement parameter', η_* ($= B_{eq}^2 R_*^2/\dot{M} v_\infty$), which characterizes the ratio between magnetic field energy density and kinetic energy density of the wind. For weak confinement $\eta_* \leq 1$, the field is fully opened by the wind outflow, but nonetheless for confinements as small as $\eta_* = 1/10$ can have a significant back-influence in enhancing the density and reducing the flow speed near the magnetic equator. For stronger confinement $\eta_* > 1$, the magnetic field remains closed over a limited range of latitude and height about the equatorial surface, but eventually is opened into a nearly radial configuration at large radii. Within closed loops, the flow is channeled toward loop tops into shock collisions that are strong enough to produce hard X-rays, with the stagnated material then pulled by gravity back onto the star in quite complex and variable inflow patterns. Within open field flow, the equatorial channeling leads to oblique shocks that are again strong enough to produce X-rays, and also lead to a thin, dense, slowly outflowing 'disk' at the magnetic equator. The polar flow is characterized by a faster-than-radial expansion that is more gradual than anticipated in previous 1D flow-tube analyses, and leads to a much more modest increase in terminal speed ($< 30\%$), consistent with observational constraints. Overall, the results here provide

a dynamical groundwork for interpreting many types of observations – e.g., UV line profile variability; red-shifted absorption or emission features; enhanced density-squared emission; X-ray emission – that might be associated with perturbation of hot-star winds by surface magnetic fields.

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Tomographic Separation of Composite Spectra. IX. The Massive Close Binary HD 115071

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We present the first orbital elements for the massive close binary, HD 115071, a double-lined spectroscopic binary in a circular orbit with a period of 2.73135 ± 0.00003 days. The orbital semiamplitudes indicate a mass ratio of $M_2/M_1 = 0.58 \pm 0.02$ and yet the stars have similar luminosities. We used a Doppler tomography algorithm to reconstruct the individual component optical spectra, and we applied well known criteria to arrive at classifications of O9.5 V and B0.2 III for the primary and secondary, respectively. We present models of the *Hipparcos* light curve of the ellipsoidal variations caused by the tidal distortion of the secondary, and the best fit model for a Roche-filling secondary occurs for an inclination of $i = 48°7 \pm 2°1$. The resulting masses are $11.6 \pm 1.1 M_\odot$ and $6.7 \pm 0.7 M_\odot$ for the primary and secondary, respectively, so that both stars are very overluminous for their mass. The system is one of only a few known semi-detached, Algol-type binaries that contain O-stars. We suggest that the binary has recently emerged from extensive mass transfer (possibly through a delayed contact and common envelope process).

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In Proceedings

XMM observations of the WR+O system Gamma Velorum

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We present *XMM-Newton* observations of the system γ Velorum at the two phases 0.1 and 0.4. The variation of the hard X-rays are interpreted as due to occultation by the WR wind. From a comparison of the observed intensity ratio to one predicted by an unclumped wind model we derive a clumping factor of 16 for the WR wind. We unequivocally identify two X-ray emitting regions: The shock zone of colliding stellar winds with temperatures up to 25 MK and a photoionized region with $T_e < 60$ kK. The revealing detection of the photoionized region is a narrow radiative recombination continuum of C VI at 25.3 Å. We suspect that shocks intrinsic to the stellar wind are a third type of X-ray source in the system and we tentatively identify the Ne IX line at 13.5 Å with this region.

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