THE $\mathrm{H}\,\mathrm{O}^{\mathrm{T}}$ STAR NEWSLETTER

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An electronic publication dedicated to A, B, O, Of, LBV and Wolf-Rayet stars and related phenomena in galaxies

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Accepted Papers

Multiwavelength Observations of the Be/X-ray binary 4U1145-619

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We report optical and infrared observations of the massive X-ray binary system 4U1145-619 (V801 Cen) which show that the circumstellar disc of the Be star component is in decline. Infrared *JHKL* magnitudes of V801Cen have been monitored from 1993 March to 1996 April. Hα spectra have been obtained throughout the same period. We find that both the infrared excess and the Balmer emission have been in decline throughout the period of observations. A 13 year optical and X-ray history of the source has been collated, revealing a possible correlation between the optical and X-ray activity. In addition, we have used *uvby*β indices, corrected for both circumstellar and interstellar effects, to calculate the physical parameters of the underlying B star.

Accepted by Monthly Notices of the Royal Astronomical Society
Preprints from `jbs@astro.soton.ac.uk`

Subtle structures in the wind of P Cyg

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The blue super-giant P Cygni has been observed with the Grand Interféromètre à 2 Télescopes (GI2T). Using high spatial resolution data at low spectral resolution *(R=3860)* of Hα and HeI6678 emission lines we clearly resolve the extended enveloppe of this Luminous Blue Variable on August 1994. The angular diameter of the equivalent uniform disk taken over the total extent of these lines corresponds to $\Phi_{H\alpha} = 5.52 \pm 0.47$ and $\Phi_{He} = 2.48 \pm 2.16$ mas respectively. We also analysed spectrally-resolved fringes in both lines for 3.4 Å width narrow channels across the emission profiles. Based on robust calibrations from two reference stars γ Lyr and α Cep we detect subtle spatial structures throughout P Cyg's wind. First: we find that the maximum extension of P Cyg occurs at -130 km.s^{-1}. This value agrees well with a picture of P Cyg where matter is radially blown outward according to the classical theory of P Cyg line profiles. Secondly: we detect a significant local phase-shift of the fringe signal at -208 km.s^{-1} which corresponds to an angular separation of 0.8 mas from the continuum source. This is interpreted as a localized blob of moving gas with enhanced brightness whose position is about 4 photospheric radii to the south of P Cyg's underlying star.

Accepted by Astronomy & Astrophysics, Main Journal
Preprints from vakili@obs-azur.fr

Emission features in Brα and Brγ spectra of normal O and B stars.

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We present high resolution Brα and Brγ spectra for 15 near main-sequence O and B stars in a broad range in $v\sin i$ and with spectral type between O9–B2. The HI infrared lines probe the outer regions in the atmosphere and the onset of the stellar wind. The slowly rotating stars (with $v\sin i < 50$ kms^{-1}) show weak, single-peaked emission features on top of a broad absorption line. The most likely explanation is a non-LTE effect in the outer photosphere causing emission at line center. The slow rotators include two β Cephei stars, both of which also show HeI (4.049 μm) emission. This indicates a significant increase in the degree of ionization in the outer layers of these B2-3 stars. For the higher $v\sin i$ stars we find two cases (out of six) in which weak, double-peaked emission is visible on top of the photospheric absorption. These two stars probably have low-density discs which are apparent only in the infrared HI lines (Zaal et al., 1995).

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Preprints from peer@astro.uva.nl

The neon abundance in WC stars – I. *ISO* SWS spectroscopy of WR 146 (WC6+O)

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We present infrared spectroscopy in the wavelength range 2.6–20μm of the WC6+O binary system WR146 (MR112) obtained with the Short Wavelength Spectrometer (SWS) on the Infrared Space Observatory (ISO). These data are combined with ground-based optical (INT) and near-IR (UKIRT) spectroscopy and theoretical continuum distributions revealing $E_{\rm B-V}$=2.8 mag, a continuum optical light ratio (WR:O)=1:2±1, a probable O8.5V companion and a distance of 750 pc. We obtain C/He=0.15 by number for the WC6 star from an analysis of near-IR recombination lines, a factor of two higher than previously estimated by Eenens & Williams (1992). We find a WC6 terminal wind velocity of 2700 km s^{-1} from the observed [Ne III] 15.5μm profile, while results from test WCE model atmospheric calculations and radio flux measurements imply $\dot{M}$=2.6×10$^{-5}M_{\odot}$yr^{-1}. An analysis of the [Ne III] 15.5μm line yields a lower limit to the neon abundance of Ne/He=3.4×10^{-3} by number. Our ISO spectra show no wind emission in either [Ne II] 12.81 μm or [Ne V] 14.32 μm from which we estimate Ne IV/Ne III≤1. The resulting bound on the neon abundance in the WC6 star is thus 3.4×10^{-3}≤Ne/He≤6.8×10^{-3}. This result is in close accord with the predicted value of Ne/He∼6×10^{-3} from stellar evolution models of WC stars (Maeder 1991), during which the products of interior nuclear burning are revealed at the stellar surface.

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Preprints from `ajw@star.ucl.ac.uk`
or by anonymous ftp to `ftp.star.ucl.ac.uk, in pub/ajw/MR112/paper.ps`
or on the web at `http://www.star.ucl.ac.uk/~pac/publications.html`

A Large Radio Nebula Around P Cygni

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We present a large set of radio observations of the Luminous Blue Variable P Cygni. These include two 6cm images obtained with MERLIN which spatially resolve the 6cm photosphere, monitoring observations obtained at Jodrell Bank every few days over a period of two months, and VLA observations obtained every month for seven years. This combination of data shows that the circumstellar environment of P Cyg is highly inhomogeneous, that there is a radio nebula extending to almost an arc-minute from the star at 2cm and 6cm, and that the radio emission is variable on a timescale

no longer than one month, and probably as short as a few days. This short timescale variability is difficult to explain. We present a model for the radio emission with which we demonstrate that the star has probably been losing mass at a significant rate for at least a few thousand years, and that it has undergone at least two major outbursts of increased mass-loss during the past two millenia.

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Preprints from skinner@stsci.edu

Cyclicities in the microvariations of LBVs I. The multi-periodic behaviour of the LBV candidate ζ^1 Sco

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Differential Strömgren *uvby* photometry of ζ^1 Sco collected during the time interval 1982–1995 is analysed together with new $VBLUW$ photometry with a complementary discussion of unpublished $JHKLM$ data. We report the discovery of a $\sim$ 1750–2200 d regular oscillation of amplitude $\sim 0\overset{\mathrm{m}}{.}01$ in all bands, and pulsation-like oscillations with at least one frequency $f_1 = 0.03155$ ($P \sim 32$ days) and a possible second frequency $f_2 \sim \frac{5}{4} f_1 \sim 0.03891 (P \sim 25.7$ days). Most likely, all such stars exhibit multi-periodic light variability. A strong noise component remaining in the prewhitened signal leads us to postulate that the driver for LBV-like eruptions is stochastic resonance. This hypothesis is supported by the historic light curve of ζ^1 Sco which shows that two centuries ago the star was about 2 magnitudes brighter, while a millenium ago it was only 1 magnitude brighter than today, an indication that ζ^1 Sco should be regarded as a candidate Luminous Blue Variable.

Accepted by A&A
Preprints from csterken@vub.ac.be

Broad Low-intensity Wings in the Emission Line Profiles of Four Wolf-Rayet Galaxies

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High-resolution spectroscopic observations have been obtained for the Wolf-Rayet galaxies He 2-10, II Zw 40, POX 4 and Tol 35. Several subregions have been selected in each slit position in order to investigate possible spatial variations in the line profiles, radial velocities and ionization conditions of the gas. The most remarkable feature of the spectra is the presence of asymmetric broad low-intensity wings in the profiles of the brightest emission lines. These spectral features are detected further out from the star-forming knots, showing linear dimensions between 300 pc and 4.1 kpc. The maximum expansion velocity measured for this gas is between 120 and 340 km s^{-1} and appears to be quite constant along the slit for all the objects. Additional general properties of the spectra are: *a*) the quoted emission line ratios are similar in the narrow and broad components, *b*) no systematic differences of the behavior of the broad and narrow components have been found along the major and minor axis of the galaxies, and *c*) the spatial distribution of the ionized gas is peaked centrally. Different

mechanisms capable of producing the observed broad spectral features are discussed: cloud-cloud collisions in virialized gas, "academic" superbubbles, champagne flows and superbubble blowout. It is concluded that superbubble blowout expanding over a cloudy medium can explain the observational properties in a reasonable manner.

Accepted by ApJ.
For preprints, contact dmendez@ll.iac.es

Submitted Papers

The orbital motion of γ^2 Velorum

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We analyze the orbital motion of γ^2 Velorum based on high resolution optical spectra obtained in 1995 and 1996. By combining our data with values from the literature we find a period $P = 78.53 \pm 0.01$ d. We determine radial velocity semi-amplitudes $K_{\rm WR} = 122 \pm 2$ km s^{-1} and $K_{\rm O} = 38.4 \pm 2$ km s^{-1} for the Wolf-Rayet star and the O star, respectively. The given errors are the standard deviations of the results from individual lines.

The inclination of the system is $i = 65°$. This result is obtained by combining $M_{\rm O}\, sin^3 i$ from the orbital analysis with the mass $M_{\rm O} = 29$ M$_\odot$, obtained from its luminosity and stellar evolution tracks. The mass of the Wolf-Rayet component is $M_{\rm WR} = 9$ M$_\odot$.

Our O star velocity curve disagrees by 15 σ from a previously published result. We have identified the reason for the disagreement in the neglect to correct for the WR emission that affects the measurements of the absorption line centers. The correction could have introduced systematic errors that may be larger than the given precision of the amplitudes. However, we can set an upper limit of $K_{\rm O} < 50$ km s^{-1} from uncorrected measurements. This yields an upper limit for the Wolf-Rayet mass of $M_{\rm WR} < 12$ M$_\odot$.

We find systematic phase-shifts between the velocity curves of some emission lines. We also observe that some (but not all) emission lines deviate significantly in the 1995 data set from the line's orbital solution defined by the 1996 observations. These phenomena may indicate that the radial velocities of the emission lines could be subject to systematic distortions and that the errors of the orbital motion are larger than the internal precision given here.

Submitted to A&A main journal.
Preprints from schmutz@astro.phys.ethz.ch
or by anonymous ftp to saturn.ethz.ch: pub/astro2/schmutz/orbit.ps

In Proceedings

The Effects of Rotation and Stellar Magnetic Field in the Nebular Shapes: LBV Nebulae and PNe

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We review the formation of bipolar nebulae, via stellar rotation, and its application to the formation of bipolar LBV nebulae and planetary nebulae. Also, the effects of the stellar magnetic field are reviewed, and applied to the formation of elliptical and highly collimated planetary nebulae. Two-dimensional hydrodynamical and magneto-hydrodynamical simulations indicate that these processes are efficient in driving bipolar and collimated outflows.

We also discuss recent 3-dimensional, magneto-hydrodynamical simulations confirming that planetary nebula jets and ansae can be obtained by magnetic collimation of their central winds. Jets and ansae form at the polar regions due to the magnetic tension produced by the magnetized winds. It is proposed that the formation of "attached" and "detached" ansae involves two and three winds, respectively. It is shown that rotating jets and point-symmetric nebular shapes can be the result of a precessing star, tidally coupled with a companion.

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Preprints from ggs@astroscu.unam.mx

The HD 5980 binary system: Components and Spectral Types

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We present a radial velocity study of the optical spectral lines of the eclipsing binary HD 5980, which recently underwent a major luminous blue variable (LBV)-type outburst. From our data we confirm that both binary components appear as stars with emission line spectra of Wolf-Rayet type. The binary component which is in front of the system during the primary eclipse, is the more massive one, and the one which produced the outburst. Absorption lines present in the pre-outburst spectrum of HD 5980 seem not to follow the orbital motion of the binary, but show variations from epoch to epoch.

To appear in Proceedings of the Workshop: Luminous Blue Variables: Massive Stars in Transition (eds. A.Nota & H.Lamers), ASPConf.Ser.

Preprints from virpi@fcaglp.fcaglp.unlp.edu.ar

or by anonymous ftp to 163.10.4.47/pub/virpi/HD5980a.ps
or on the web at http://sol.stsci.edu/∼rbarba/full_papers/kona_hd5980b.ps.gz

Evolution of the Optical Spectrum and Hydrogen Abundances in HD 5980

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We review the several types of spectral variations observed in the optical spectrum of HD 5980, the eclipsing binary in the Small Magellanic Cloud that unexpectedly underwent a luminous blue variable (LBV)-type outburst in 1994. We have also determined the Hydrogen presence in the spectrum, and find a correlation between the spectral type exhibited by the star along the outburst cycle, and the deduced amount of Hydrogen.

To appear in Proceedings of the Workshop: Luminous Blue Variables: Massive Stars in Transition (eds. A.Nota & H.Lamers), ASPConf.Ser.
Preprints from virpi@fcaglp.fcaglp.unlp.edu.ar
or by anonymous ftp to 163.10.4.47/pub/virpi/HD5980b.ps
or on the web at http://sol.stsci.edu/∼rbarba/full_papers/kona_hd5980a.ps

Ring Nebulae around Evolved Massive Stars: Observational Clues

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Observations of ring nebulae associated with evolved massive stars (Wolf-Rayet and luminous blue variables) are powerful tools for understanding the interaction of stellar winds and ejecta with the circumstellar medium. Moreover, the morphological, dynamical and chemical properties of these nebulae reflect the past history of the progenitor star. In this paper, I review and discuss some important observational properties (census, morphology, kinematics, chemical abundances, and progenitors of the central stars) related to ring nebulae.

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Preprints from cel@iac.es
or by anonymous ftp to ftp.iac.es/pub/cel

Meetings

ANNOUNCEMENT :
The *Groupement de Recherches du CNRS* "Milieux circumstellaires" (France), the *Université de Montréal* (Québec, Canada) and the *Université Louis Pasteur* (Strasbourg, France) are pleased to announce the following RESEARCH SCHOOL.

Non-Equilibrium Radiative Hypersonic Flows
Theoretical, Observational and Numerical Aspects in Astrophysics and Aerospace Industry

Mt. Sainte Odile (near Strasbourg, France), September 22-25, 1997

Non-equilibrium radiative hypersonic flows are relevant both to astrophysics (e.g. stellar winds, choc propagation, interactions in binary systems) and to aerospace industries (e.g. flows around fast bodies in planetary atmospheres). The techniques used in both areas differ and complement each other: laboratory experiments provide constraints that cannot be obtained directly from astrophysical observations, but astrophysical objects extend the data with examples of extreme physical conditions.

The aims of this school are to present the current status of theory, observations, experiments and numerical simulations in the field, as well as to facilitate exchanges between the astrophysical and industrial research communities. Astrophysicists, engineers and post-graduate students are invited to participate.

Scientific committee:
A. Acker (Observatoire de Strasbourg, France)
J.-P. J. Lafon (Observatoire de Paris, France)
A. Moffat (Université de Montréal, Québec, Canada)

Preliminary programme:

• Hypersonic flows
— Theory (E.Huguet, Observatoire de Paris-Meudon & R.Brun, CNRS Marseille)
— Numerical simulation (A.Vincent, CERCA Montréal & C.Marmignon, ONERA France)
— Applications in Space industry (A.Broc, Observatoire de Paris-Meudon & L.Marraffat, ESTEC/ESA)

• Stellar winds, general aspects
— Observations (H.Lamers, Utrecht Univ., the Netherlands)
— Theory (R.Kudritzki, Univ. München, Germany)

• Stellar winds, instabilities and variability
— Observations, theory and simulations (A.Feldmeier, Univ. Berlin, Germany)

• Stellar winds, dust
— Formation, chemistry (J.-P.J.Lafon, Observatoire de Paris-Meudon, France & N.Berruyer, Observatoire de Côte d'Azur, France)

• Winds around young stars
— Stellar winds (P.Bastien, Univ. de Montréal, Canada)
— Winds & rapid rotation, disk formation (S.Owocki, Univ. Delaware)

• Winds around evolved stars and their interaction with the ISM
— Observations, massive and low mass stars (A.Acker, Univ. de Strasbourg, France & N.St-Louis,

Univ. de Montréal)
— Theory and model construction (G.Mellema, Univ. of Sweden)

• Colliding winds in binary systems
— Observations (A.Moffat, Univ. de Montréal)
— Theory (R.Walder, Zürich Univ., Switzerland)

• Discussion and future prospects.

More information on the web at
`http://www.obspm.fr/departement/dasgal/circumstellar.html`
or at `http://astro.u-strasbg.fr/~odile/colloque97.html`
or via e-mail to `odile@astro.u-strasbg.fr`