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

$\star$

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

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editor: Philippe Eenens http://www.inaoep.mx/∼eenens/hot/

eenens@inaoep.mx http://www.star.ucl.ac.uk/∼hsn/index.html

From the editor

If you receive this newsletter by e-mail, how do you erase the header before running LaTeX? For an easy way to delete mail headers (under UNIX), create the following file (in your path) and call it `behead`:

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o) exec sed '1,/^$/d' ;;
*) for i
   do sed '1,/^$/d' "$i"
   done
   ;;
esac
```

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```
behead file.mai > file.tex
```

Contents of this newsletter

Accepted Papers

X-ray emission from Ap-Bp stars: a magnetically confined wind-shock model for IQ Aur

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We present the results of a *ROSAT*-PSPC pointed observation on the hot A0p star IQ Aur (HD 34452). The X-ray luminosity obtained is $L_X = 4.0 \times 10^{29}$ erg s^{-1} ($\log L_X/L_{\rm Bol} \simeq -6.9$) and the plasma temperature is $T_X = 0.29$ keV. Since A and B stars have no known magnetic activity, the only possibility is to invoke a wind origin for this emission. On IQ Aur, the expected mass loss rate driven by stellar radiation is small, around 10^{-10}- 10^{-11} M$_\odot$yr^{-1} with $v_\infty = 800$ km s^{-1}, so that the kinetic energy flux of the wind is not much larger than the observed X-ray emission. This implies that the X-ray emission from IQ Aur must arise from a very efficient process. These constraints, together with the large observed magnetic field of IQ Aur, lead us to propose that the confinement of the wind by the magnetic field leads to a collision from the wind components of the two hemispheres in the closed magnetosphere, leading to a strong shock. In this model the magnetic field confines the wind and also affects the mass loss rate.

We propose a self-consistent approach for the X-ray emission of IQ Aur, using radiatively driven wind models based on the stellar parameters of IQ Aur and including the effect of magnetic confinement of the wind. We also model the whole postshock region. We show that our shock model is able to satisfy the constraints on the observed X-ray luminosity and temperature. The model also leads to the formation of a disk at the magnetic equator corotating up to $r \lesssim 4R_*$. We show that ambipolar diffusion of hydrogen in the disk or current sheet formation due to equipartition between the disk and the magnetic field might play a significant role in emptying the magnetosphere.

We discuss the interplay between mass loss and particle diffusion. Our computations suggest that the onset of a wind on IQ Aur is very recent, so that the abundance anomalies at the stellar surface have not yet been removed by the outflow, or that the wind exhibits transient phases due to the mutual feedback between the wind and abundance anomalies.

Finally, we point out that our wind-shock model provides a very convenient framework to explain the radio emission of Ap-Bp stars. It has been shown that the emission mechanism is optically thick gyrosynchrotron, but instead of (or in addition to) the previously invoked acceleration by magnetic reconnection in current sheets, we propose that the electrons are accelerated by second-order Fermi acceleration mechanism ("stochastic" acceleration) often invoked for the acceleration of solar flare flare particles. We show that electrons accelerated by the wind shock easily reach the required energies for radio emission in the GHz band throughout the magnetosphere.

Given the success of our model in explaining IQ Aur, we think that it has a fairly general application to magnetic Ap-Bp stars. The wind-shock model also provides a unified explanation for both the X-rays and the radio emission from these stars.

Accepted by Astronomy & Astrophysics

Preprints from babel@astrophysik.uni-kiel.de

The WO stars. IV. Sand 5: a variable WO star

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We report the results of 10 years (August 1986–July 1996) of intermediate and low resolution spectroscopic observations of the WR star Sand 5 (WR 142), the nearest and less studied member of the small WO–subgroup which is located in the peculiar open cluster Berkeley 87. The wide spectral coverage (306–716 nm) and high S/N ratio, allowed us to measure in Sand 5 numerous emission features, and to separate most line blends. We have identified emission lines belonging to a very wide ionization range, from He II, C III, C IV, O IV, up to O V, O VI, and, notably, O VIII. The line broadness varies from 1600 km/s for O VIII to 3000/4600 km/s (O VI), 4100 km/s (O V), 4700/6200 km/s (C IV), and 5600 km/s (He II), which implies a ionization stratification in the wind and an acceleration of the outflowing matter from $\leq$1600 km/s up to the wind terminal velocity of $\sim$6000 km/s. During the extensive period covered by our observations the spectrum of Sand 5 has remained essentially constant. However we have noticed a marked fading of the contribution of He II to the 467 nm emission in 1992–1996, while the O VIII 606 nm doublet was not detected in 1987 and in 1989, suggesting that both events might be associated with irregular long term wind structure variation. From the analysis of the continuum energy distribution we argue for a large interstellar extinction of E_{B-V}=2.1, with a reddening excess of about δE_{B-V}=0.4 local to the star, and a steep power–law $\lambda^{-3.85}$ distribution of the stellar continuum. We finally discuss the possible evolutionary state for Sand 5.

Accepted by Astronomy & Astrophysics

Preprints from `polcaro@saturn.ias.fra.cnr.it`

$H-$Band Spectroscopic Classification of OB Stars

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We present a new spectroscopic classification for OB stars based on $H-$band (1.5 μm to 1.8 μm) observations of a sample of stars with optical spectral types. Our initial sample of nine stars demonstrates that the combination of He I 1.7002 μm and H Brackett series absorption can be used to determine spectral types for stars between $\sim$ O4 and B7 (to within $\sim \pm$ 2 sub–types). We find that the Brackett series exhibits luminosity effects similar to the Balmer series for the B stars. This classification scheme will be useful in studies of optically obscured high mass star forming regions. In addition, we present spectra for the OB stars near 1.1 μm and 1.3 μm which may be of use in analyzing their atmospheres and winds.

Accepted by the AJ

Preprints from `rblum@casa.colorado.edu`
or by anonymous ftp to `degobah.colorado.edu/pub/rblum/Hband/`
or on the web at `ftp://degobah.colorado.edu/pub/rblum/Hband/`

Supernova Remnants in OB Associations

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We use the sample of supernova remnants (SNRs) in OB associations in the Large Magellanic Cloud (LMC) to study how interstellar environments affect the physical properties of SNRs. Some of these SNRs have been identified by the three classical SNR signatures - bright X-ray emission, nonthermal radio emission, and enhanced [S II]/Hα ratio; the others have been diagnosed by bright X-ray emission from superbubbles. We have obtained long-slit echelle observations of these 14 SNRs and their surroundings to search for high-velocity shocked gas in the SNRs and to examine the structure of the ambient interstellar medium. Not all SNRs show detectable high-velocity ($\Delta V \geq 100$ km s^{-1}) gas. SNRs in H II regions all show classical SNR signatures and high-velocity gas, while SNRs in superbubbles often show only diffuse X-ray emission but not the other SNR signatures. Using *ROSAT* X-ray observations of two superbubbles, N51D and N44, we illustrate quantitatively that SNR shocks in the interiors of superbubbles can produce bright, detectable X-ray emission for *ROSAT* and *Einstein* detectors, but not enough Hα emission for echelle observations using a 4-m class telescope. The wide variety of SNR properties can be explained by the differences in their interstellar environments.

Accepted by the Astronomical Journal (1997 May issue)

Preprints from `chu@astro.uiuc.edu`
or on the web at `http://www.astro.uiuc.edu/~chu/preprints/lmcobsnr.ps`

The Hanle Effect as a Diagnostic of Magnetic Fields in Stellar Envelopes
I. Theoretical Results for Integrated Line Profiles

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The Hanle effect concerns the modification of polarized resonance line scattering by magnetic fields, thus it can be used as a diagnostic of stellar magnetic fields. The Hanle effect has been used to determine the field strength and distribution of magnetic structures present in prominences of the Sun. To investigate its potential use in stellar astronomy, the simplified case of an optically thin axisymmetric ring illuminated by a stellar point source is considered. The results are then used to derive the polarization from polar plumes, equatorial disks, and spherical shells. The integrated line polarization is calculated for axisymmetric rings with a variety of magnetic field orientations, and in every case the polarization is proportional to $\sin^2 i$ (where i is the viewing inclination), just as in the zero field case. It is also found that the Hanle effect can significantly alter the integrated line polarization. In some cases the position angle of the polarization in the line can be rotated by 90° relative to the zero field case. We consider the Hanle effect as a possible diagnostic of magnetic fields in stellar winds with prominent UV and visible resonance lines. For these lines the diagnostic has sensitivity in the range of 1-1000 Gauss. The Zeeman effect is not normally applicable for diagnosing magnetic fields in stellar winds in the sub-kiloGauss range; thus, the Hanle effect should provide an especially useful new method of determining magnetic fields in stars other than the Sun. Possibilities for measuring the fields in early type stars using UV observations is discussed.

Accepted by Astrophysical Journal
Preprints from rico@astro.gla.ac.uk

A Photometric System for Detection of Embedded Wolf-Rayet Stars

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We describe the performance of a photometric system designed for detection of WR stars in the near infrared region (1μm) and based on a combination of narrow band filters and a CCD detector. The system is sensitive to Of and faint lined WN and WC stars and suitable for obscured regions of star formation in our Galaxy.

Accepted by PASP
Preprints from damineli@jila02.colorado.edu
or by anonymous ftp to degobah.colorado.edu *in* /pub/damineli/wr *files* wr*.ps

Submitted Papers

Wind Velocity Variations in the LBV-type Eruption of the Wolf-Rayet Binary HD 5980

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Variations in the wind velocities and UV luminosities of the WR system HD 5980 are presented, indicating that the LBV-type eruption of 1994 can be characterized in terms of the expansion of a pseudophotosphere accompanied by a reduced expansion velocity of the wind. An estimate of the stellar parameters indicates that the erupting star is very massive ($M > 40\ M_{\odot}$) and luminous ($L > 10^6\ L_{\odot}$), and that during the eruption its radius extended beyond the binary orbit ($R_* > 100\ R_{\odot}$). The development of a fast wind (~ -2100 to -2900 km s^{-1}) following the slow wind (~ -500 to -800 km s^{-1}) eruptive phase is observed. Absorption components at -1100 to -1300 km s^{-1} which appear in early 1995 may be associated with the interaction of the fast and slow winds, or may be indicating a bimodal velocity distribution, in the erupting star. Orbital phase-dependent variations in the $\lambda 1300$ $\AA$ continuum levels may be attributable to Fe V+Fe VI lines arising in the wind-wind collision region between both stars.

Submitted to ApJ
Preprints from gloria@astroscu.unam.mx

η Carinae: A Long Period Binary?

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We present new observations of η Carinae, strongly suggesting that it is a binary system. High dispersion measurements of the broad Paγ emission line show periodic radial velocity variations that are nicely explained by a star in a highly eccentric orbit. Velocity characteristics of the system imply massive components, in accord with the luminosity and spectral characteristics. Strong and variable wind–wind interactions are predicted to take place in η Carinae on the basis of the orbital elements and physical characteristics of the components. The low excitation event predicted for the end of 1997 is underway, confirming the high coherence of the 5.52 year cycle and adding confidence to η Car as a binary system. We associate this event with periastron passage. A conclusive demonstration of the binary orbit is still pending, but the present work has the advantages of bringing this mysterious object within a stellar evolution framework, and, for the first time in its history, predictions suitable for testing against future observations.

Submitted to New Astronomy
Preprints from `damineli@jila02.colorado.edu`
or by anonymous ftp to degobah.colorado.edu *in* /pub/damineli/etacar *file* etabinar.ps

The *Hipparcos* distance determination of the Wolf-Rayet system γ^2 Velorum (WC8+O) and its ramifications

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Hipparcos measured the distance to the Wolf-Rayet WC8+O spectroscopic binary γ^2 Vel as $d = 258^{+41}_{-31}$ pc and the distance the O4I(n)f star ζ Pup as $d = 429^{+120}_{-77}$. Adopting for γ^2 Vel an interstellar extinction of $A_v = 0.06$ mag, this implies an absolute magnitude M_v = –5.4 mag for the WC8+O binary system. Given that the binary components have a magnitude difference Δm = 1.4 mag, we derive M_v(WC8) = –3.7 and M_V(O) = –5.0 mag. The latter indicates an O8.5III rather than an O9I companion, as was adopted during the last 25 yr. Apparently γ^2 Vel is not a member of, but a

foreground object before the open cluster Cr 173 and the association Vel OB2. Given a re-assessment of the distance of the Gum Nebula, γ^2 Vel is still one of its ionizing sources, while ζ Pup appears to be located at the back of the Gum Nebula. Consequences of the *Hipparcos* distance determination of γ^2 Vel for its mass, mass loss rate and luminosities at various wavelengths are discussed.

Submitted dd. 7 March 1997 to A&A as Letter to the Editor
Preprints from k.vanderhucht@sron.ruu.nl
or by anonymous ftp to saturn.sron.ruu.nl/pub/karelh/UPLOADS

Fundamental stellar parameters of ζ Pup and γ^2 Vel from HIPPARCOS data

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We report parallax measurements by the HIPPARCOS satellite of ζ Puppis and γ^2 Velorum. The distance of ζ Puppis is $d = 429^{+120}_{-77}$ pc, in agreement with the commonly adopted value to Vela OB2. However, a significantly smaller distance is found for the γ^2 Vel system: $d = 258^{+41}_{-31}$ pc.

The total mass of γ^2 Vel derived from its parallax, the angular size of the semi-major axis as measured with intensity interferomentry, and the period is $M(WR+O) = 29.5 \pm 15.9\,\mathrm{M}_\odot$. This result favors the orbital solution of Pike et al. (1983) over that of Moffat et al. (1986). The stellar parameters for the O star companion derived from line blanketed non-LTE atmosphere models are: $T_{\rm eff} = 34000 \pm 1500$ K, $\log L/L_\odot = 5.3 \pm 0.15$ from which an evolutionary mass of $M = 29 \pm 4\,M_\odot$ and an age of $4.0^{+0.8}_{-0.5}$ Myr is obtained from single star evolutionary models. With non-LTE model calculations including He and C we derive a luminosity $\log L/L_\odot \sim 4.7 \pm 0.2$ for the WR star. The mass-luminosity relation of hydrogen-free WR stars implies a mass of $M_{\rm WR} \sim 5 \pm 1.5\,M_\odot$.

From our data we favor an age of ~ 10 Myr for the bulk of the Vela OB2 stars. Evolutionary scenarios for ζ Puppis and γ^2 Vel are discussed in the light of our results.

Submitted to ApJ Letters
Preprints from schaerer@stsci.edu

In Proceedings

Rotation: a fundamental parameter of massive stars

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We show how rotation can affect the structure, evolution and fate of massive stars. Internal mixing

of matter and angular momentum shifts and spreads the mass-luminosity relation for massive main sequence stars, transports H-burning products to the surface of these stars, alters the character of isochrones, and makes more stars explode as supernovae. Rotation can enhance and produce mass loss, alter and disperse the initial-final mass relation, produce and shape LBV nebulae, and also lead to more supernovae. Many of these effects remain quantitatively to be explored. However, for most of them there is overwhelming observational evidence showing their qualitative significance. There is no doubt that the initial rotation rate is a truly fundamental parameter for massive stars, which is equally important as the initial mass and metallicity.

To appear in Proc. of IAU-Symposium No. 189 "Fundamental Stellar Properties: the Interaction between Observation and Theory", T. Bedding, A. Booth, and J. Davis, eds., Kluwer

Preprints from ntl@astro.physik.uni-potsdam.de
or on the web at http://www.mpa-garching.mpg.de/ ahg/Publications/Publications.html

He I lines in luminous galactic B[e] stars

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Spectral similarities between LBV's and hot emission-line objects have now been noted for many years. Among these hot stars, the B[e]'s share with LBV's spectra line emissions due to H, He I, permitted and forbidden transitions of O, Fe^{+} and Fe^{++}. Among ten galactic B[e] stars recently observed at Observatoire de Haute-Provence, we selected three objects which do not seem to belong to the HAEBE stellar group. These are MWC 349A, MWC 162 (also known as OY Gem or HD 51585) and MWC 314 (or BD+14 3887). We discuss the behavior of the He I lines fluxes. Observed line-ratios to 447.1 nm fit rather poorly with theoretical values computed either from nebular recombination (case B) or from model atmosphere calculations.

To appear in: *Luminous Blue Variables: Massive Stars in Transition,* **eds. A. Nota, H.J.G.L.M. Lamers, ASP Conf. Ser.**

For preprints, contact fremat@umh.ac.be

Theories of Stellar Winds

Henny J.G.L.M. Lamers

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Stellar winds can be driven by various mechanisms, specified by the main force that is responsible for the wind. These are:
(1) Coronal winds, driven by gas pressure at high temperature
(2) Line driven winds, due to radiation pressure in spectral lines
(3) Dust driven winds, due to radiation pressure on dust

(4) Pulsation driven winds, due to oscillating motions of the photosphere
(5) Sound wave driven winds, due to wave pressure of acoustic waves
(6) Alfven wave driven winds, due to wave pressure by Alfven waves
(7) Magnetic rotating winds, due to magnetic corotation
We describe the basic theory of stellar winds with momentum input due to a force or with energy input and we formulate the five laws of stellar winds.

To appear in *Lecture Notes of Physics*, **proceedings of a Summer School of the European Astronomy Doctoral Network, edited by J.P. de Greve**
Preprints from `hennyl@sron.ruu.nl`

The Theory of Line Driven Stellar Winds

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We describe the theory of line driven winds. First we explain the concept and give some simple estimates. Next we derive expressions for the radiative acceleration due to lines. The equation of motion for a line driven wind from a star in the point source limit is solved. This gives simple analytical expressions for the predicted mass loss rates and the terminal velocities. The equations show that $\dot{M} \sim L_*^{1.6}$ and $v_\infty \sim v_{\rm esc}$, in agreement with the observations. The theory is refined by a correction for the finite size of the star. We also discuss the stability of line driven wind and show that these winds are intrinsically unstable. This explains the observed super-ionization and the X-rays from line driven winds. We compare the predictions with observations and show that the theory is very succesful in explaining the overall features of the winds of hot stars.

To appear in *Lecture Notes of Physics*, **proceedings of a Summer School of the European Astronomy Doctoral Network, edited by J.P. de Greve**
Preprints from `hennyl@sron.ruu.nl`

Bibliography

The years 1993–1997 of the Wolf-Rayet bibliography have been updated on 20 February 1997. The bibliography can be found on the Web at URL
http://www.inaoep.mx/∼eenens/hot/bibli/
or
http://www.star.ucl.ac.uk/∼hsn/bibli/index.html
or on request from the author, Karel A. van der Hucht: `K.vanderHucht@sron.ruu.nl`

Meetings

FIRST ANNOUNCEMENT

ESO Workshop on

Cyclical Variability in Stellar Winds

recent developments and future applications

14-17 October 1997

ESO Headquarters
Garching bei München, Germany

Variability is a fundamental property of stellar winds. In recent years it has become clear that in many cases the observed variations show a cyclical behaviour. This is a property that **hot- and cool-star winds** seem to have in common, although the physical mechanism driving these winds is different.

Topics to be covered include:

- Wind acceleration mechanisms
- Observations of cyclical wind variability (hot and cool stars)
- Latest solar wind results
- Variability in pre-main-sequence winds
- Processes affecting the emergence of the wind
- Modelling time-dependent behaviour stellar winds
- MUSICOS 1996 results
- Future developments

Scientific Organizing Committee:
T. Böhm (Germany), A. Cameron (UK), C. Catala (France), L. Hartmann (USA), H. Henrichs (The Netherlands), L. Kaper (Germany), H. Lamers (The Netherlands), K. MacGregor (Chair, USA), S. Owocki (USA), J. Puls (Germany), O. Stahl (Germany)

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Please contact for a registration form: windvar@eso.org
For more info: http://www.eso.org/windvar

Workshop on B[e] stars

LOCATION
The workshop will be held on the campus Observatoire de Paris/ Institut d'Astrophysique de Paris, France **June 9-12 1997**. It is organized with the financial suport of the Observatoire de Paris and the CNRS.

SCIENTIFIC COMMITTEE
J. Cassinelli (USA), L. Houziaux (Belgium), A.M. Hubert (France), C. Jaschek (France), H. Lamers (The Netherlands), J.M. Marlborough (Canada), A. Miroshnichenko (Russia).

PRELIMINARY PROGRAM
- Current definition of B[e] stars. Comparison of galactic and extragalactic (in the SMC and the LMC). Similarities and differences with Herbig Be/Ae, "normal" Be stars, symbiotic objects.

- Distribution of B[e]'s in our Galaxy and a review of global properties like absolute magnitude, distances, extinction, radial velocities and proper motions.

- Spectroscopic observations in various wavelength ranges (X-rays, UV, optical, IR, mm and radio) and variability.

- Photometry, polarimetry and interferometry. Variability.

- Modelling of B[e]'s with dusty environments (winds, discs, bipolar flows)

- B[e]'s and related objects in the evolutionary sequence: pre-main-sequence, post-main-sequence?

- Conclusions and redefinition of the group.

INVITED SPEAKERS
J. Bjorkman, J. Cassinelli, C. Jaschek, H. Lamers, N. Langer, A. Miroshnichenko, S. Owocki, L. Waters, F.Z. Zickgraf, J. Zorec.

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