THE HOT STAR NEWSLETTER

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

No. 28 March 1997

editor: Philippe Eenens http://webhead.com/~sergio/hot/

eenens@andromeda.cimat.mx http://www.star.ucl.ac.uk/~hsn/index.html

From the editor

Guanajuato is a lovely colonial town 350 km North of Mexico City. It is renowned for its silver mines, which used to be among the best in colonial times. Nowadays it is a touristic attraction, especially during the Cervantes festival.

The University of Guanajuato recently opened a department of astronomy, with all the challenges that this means. I could not resist the appeal of a new adventure. As a consequence, the Hot Star Newsletter has found a new home. For some time, the homepages will only be accessible through its WWW mirrors. The temporary electronic address is:

eenens@andromeda.cimat.mx

Thank you for your comprehension and patience while a definitive internet access is being installed.

Contents of this newsletter

Accepted Papers

The Possibility of Forming Blue Supernova Precursors in the AB Scenario for the Evolution of Massive Close Binary Systems

E.I. Staritsin

Astronomical Observatory, Ural State University, pr. Lenina 51, Yekaterinburg, 620083 Russia

It is shown that, in the AB scenario for the evolution of a close binary system, the secondary component in the system remains a blue supergiant after the end of mass exchange. This will occur if its mass grows by 20-80%, the system loses no more than 70 % of its original orbital angular momentum, and there is no mixing of material from the convective core and the upper layers in the hydrogen burning stage. The mass and luminosity of the blue supergiant are determined by the initial masses of the binary components and the extent to which the mass exchange is nonconservative. The rate of formation of blue supernova precursors in Galaxy by this mechanism is estimated to be $(6-18)\cdot 10^{-5} yr^{-1}$.

Accepted by Astronomy Reports, vol.40

Preprints from `Eugenij.Staritsin@usu.ru`

A K-band Spectral Atlas of Wolf-Rayet Stars

Donald F. Figer[1], Ian S. McLean[1], & Francisco Najarro[2]

[1] Division of Astronomy, Department of Physics & Astronomy,
University of California, Los Angeles, CA 90095-1562

[2] Institute für Astronomie und Astrophysik, Universitäts-Sternwarte München,
München, Germany

We present K-band spectra (R $\sim$ 525) of 38 northern Galactic WR Stars, of which, 16 are WC, 19 are WN, 2 are WN/WC, and 1 is WO. The spectra have the expected trend of stronger lines for higher ionization species with earlier spectral subtype. Spectra for the late WC stars can appear to have weak emission lines, an effect due to different amounts of dust dilution in the individual stars. There are also differences in spectral morphology for stars within other subtypes. In general, the spectra for all WC stars earlier than WC9 tend to be quite similar, while the spectra for WN subtypes are more easily differentiated. Several previously unidentified emission lines are seen in the spectra, most notably, features near 2.247 μm and 2.368 μm in late-type WN stars, and one near 2.222 μm in late-type WC stars. We attribute the 2.247 μm line to a ionN3 transition and argue that it might provide the best method for discriminating between WNL and OIf^{+} stars in the K-band.

We investigate the behavior of the 2.11 μm (ionHe1+ionN3), 2.166 μm (ionH1+ionHe1+ionHe2), and 2.189 μm (ionHe2) emission lines in WN types and find that these lines provide for accurate discrimination within the sample to within 1 subtype. From this investigation, it appears that the ratio of $W_{2.189\,\mu m}/W_{2.11\,\mu m}$ is sensitive to subtype and shows the least dispersion within subtypes. In addition, we find that the $W_{2.189\,\mu m}/W_{2.166\,\mu m}$ ratio also scales with subtype in a well-behaved manner once it is corrected for contamination of the 2.166 μm line by ionHe2 14-8 and for the presence of an O-star

We also investigate the behavior of the 2.058 μm (ionHe1), 2.08 μm (ionC4), and the 2.11 μm (ionC3+ionHe1) emission lines in WC types. The ratio of $W_{2.08\,\mu m}/W_{2.11\,\mu m}$ correlates with subtype; however, it is not easy to distinguish between individual subtypes earlier than WC8 by just using this quantity. The dominance of the 2.058 μm line in WC9 types distinguishes this subtype from all other WC subtypes. Two WC9 stars in our sample have nearly featureless spectra due to dust dilution.

It is possible to classify a WR star to within one subtype in the WN sequence based upon the sample in this atlas. The similarity of WC spectra makes it difficult to distinguish amongst individual subtypes earlier than WC8.

Accepted by ApJ Supp.
Preprints from `http://www.astro.ucla.edu/~figer/papers.html`

A two-component infrared nebula around HR Car

R.H.M Voors[1,2] and L.B.F.M. Waters[3,4] N.R. Trams[5] H.U. Käufl[6]

[1] Astronomical Institute, University of Utrecht, Princetonplein 5, 3508 TA Utrecht, The Netherlands

[2] SRON Laboratory for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands

[3] Astronomical Institute Anton Pannekoek, University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands

[4] SRON Laboratory for Space Reserach, PO Box 800, 9700 AV Groningen, The Netherlands

[5] ISO Science Operations Center, Astrophysics Division of ESA, PO Box 50727, E-28080 Villafranca, Madrid, Spain

[6] European Southern Observatory, D-8046 Garching bei München, Germany

We present mid-infrared imaging of the LBV HR Car and its surrounding nebula. The 10μm broadband N image reveals a geometry which is not point symmetric with respect to the central star on an arcsecond scale. The 12.8μm narrow-band [Ne II] image shows a clumpy structure which does not follow the N-band distribution. In addition, we detect a faint and probably clumpy outer nebula about 15 arcsec across.

The morphology of the infrared nebula and in particular its asymmetry is not at all in agreement with the large-scale structures as seen in optical images. Three different episodes of shell ejection can now be distinguished for HR Car: the arc-like structures seen in the optical, about 35 arcsec across, the faint IR nebula seen in the N-band, about 15 arcsec across, and the small, irregular nebula less than 8 arcsec across. The main conclusion we draw from this is that the geometry of mass-ejections in HR Car is highly time-dependent and that multiple shell ejections can occur in LBVs.

The distance of the small IR nebula from the central star can be well explained by a dust shell that is composed of silicates and is in radiative equilibrium with the central star.

Accepted by A&A Letters
Preprints from `voors@fys.ruu.nl`
or by anonymous ftp to `ruunat.fys.ruu.nl/pub/astronomy/voors/hrcar/hrcar_let.ps`
or on the web at `http://stkwww.fys.ruu.nl:8000/~voors/Home.html`

Dynamic Processes in Be Star Atmospheres. V. Helium Line Emissions from the Outer Atmosphere of λ Eridani

Myron A. Smith[1], D. H. Cohen[2], I. Hubeny[3], K. Plett[1], G. Basri[4], C. M. Johns-Krull[4], J. J. MacFarlane [5], and R. Hirata[6]

[1]CSC/IUE Observatory, Sciences Programs, Computer Sciences Corp. 10000A Aerospace Rd., Lanham-Seabrook, MD 20706, msmith@nobel.gsfc.nasa.gov

[2]Department of Astronomy, University of Wisconsin, Madison, WI 53706,

[3]Universities Space Research Association, Goddard Space Flight Center, Code 681, Greenbelt MD 20771,

[4]Department of Astronomy, University of California, Berkeley, CA 94720

[2], 5Fusion Technology Institute, University of Wisconsin, Madison, WI, 53706,

[6]Department of Astronomy, University of Kyoto, 606 Japan

The He I lines of the mild B2e star λ Eri often exhibit rapid, small amplitude emissions can occur at random places in their photospheric lines, even when the star is in a "non-emission state." New simultaneous observations of the triplet λ5876 and singlet λ6678 lines show that the emission ratio for these lines is near unity, contrary to the predictions of either non-LTE model atmospheres or nebular recombination theory.

Several He I emission events point to the formation of short-lived structures near the star's surface. On 1995 September 12 the λ6678 line exhibited a strong ($0.13 I_{cont}$) emission lasting some 20 minutes. The rapid decay of this feature implies a density of $\geq 10^{11.5}$ cm^{-3} for an emitting plasma structure near the star. This value is consistent with density estimates for slabs which may be responsible for ephemeral "dimples" in this star's He I lines on other occasions. We argue that photospheric helium emissions during Hα-quiescent phases are caused by foreground material and ask what mechanism might produce these features against the stellar background.

To answer this question we have simulated He I line emission from model slabs having various properties and suspended over the star. We find that illumination by a source of EUV or X-ray flux depletes the He I column density so that it is difficult to form observable He I lines. A more interesting set of conditions occur for slabs with high densities ($\sim 10^{12}$ cm^{-3}) and moderately large optical thicknesses in optical He I lines. Under these modified assumptions modest amounts of emission can be reproduced in singlet and triplet lines, and in the observed ratio. The key to producing this emission is for the slab to feel its own Lyman continuum radiation. This condition causes λ584 and other resonance lines to partially depopulate the ground state and to overpopulate the first few excited levels, insuring that the departure coefficients of relevant atomic levels approach common values. The second necessary ingredient is a high density, which tends to equalize the departure coefficients of excited levels through recombinations and through redistribution of electrons among the l-sublevels. The combination is a kind of "Lyman-pumped recombination" because it relies on the Lyman continuum being marginally optically thick. Our results are consistent with studies of He I emission from planetary nebulae, symbiotic variables, and AGN, and may have a bearing on other "detached atmospheres" problems as well. This study appears to be the first application of such a recombination mechanism to a quasi-photospheric setting.

Accepted by Ap J 97 May 20

Preprints from `MSMITH@iuegtc.gsfc.nasa.gov`

Dynamic Processes in Be Star Atmospheres. VI. Simultaneous X-ray, Ultraviolet, and Optical Variations in λ Eridani

Myron A. Smith[1], **T. Murakami**[2], **H. Ezuka**[2], **B. G. Anandarao**[3], **A. Chakraborty**[3], **M. F. Corcoran**[4], **and R.Hirata**[5],

[1]CSC/IUE Observatory, Sciences Programs, Computer Sciences Corp. 10000A Aerospace Rd., Lanham-Seabrook, MD 20706, msmith@iue.gsfc.nasa.gov

[2]Institute of Space and Astronautical Science, Kanagawa 229, Japan,

[3]Physical Research Laboratory, Ahmedabad, 380009, India,

[4]Universities Space Research Association, Goddard Space Flight Center, Code 666, Greenbelt MD 20771,

[5]Department of Astronomy, University of Kyoto, 606 Japan,

We document the results of a simultaneous wavelength monitoring on the B2e star λ Eri. This campaign was carried out from ground stations and with the ROSAT, ASCA, IUE, and Voyager 2 space platforms during a week in February-March 1995; a smaller follow-up was conducted in September 1995. During the first of these intervals λ Eri exhibited extraordinary wind and disk-ejection activity. The ROSAT/HRI X-ray light curves showed no large flares such as the one the ROSAT/PSCA observed in 1991. However, possible low level fluctuations in the February-March ROSAT data occurred at the same time as unusual activity in Hα, He I λ6678, He II λ1640, and the C IV doublet. For example, the hydrogen and helium lines exhibited an emission in the blue half of their profiles, probably lasting several hours. The C IV lines showed a strong high-velocity Discrete Absorption Component (DAC) accompanied by unusually strong absorption at lower velocities. The helium line activity suggests that a mass ejection occurred at the base of the wind while the strong C III (Voyager) and C IV (IUE) lines implies that shock interactions occurred in the wind flow. It is not clear that the X-ray elevations are directly related to the strong C IV absorptions because the former changed on a much more rapid timescale than absorptions in the C IV lines.

Within hours of the mild X-ray flux variations found by ROSAT on February 28, the Voyager UVS observed a "ringing" that decayed over three 3-hr. cycles. The amplitude of these fluctuations was strong (50%) at $\lambda\lambda$950-1100, decreased rapidly with wavelength, and faded to nondetection longward of λ1300. Various considerations indicate that these continuum variations were not due to an instrumental pathology in the UVS. Rather, they appear to be due to a time-dependent flux deficit in the $\lambda\lambda$950-1250 region. We outline a scenario in which a dense plasma structure over the star's surface is heated and cooled quasi-periodically to produce such flux changes. Observations of new examples of this phenomenon are badly needed. Amateur astronomers can make a significant contribution to its understanding by searching for ringing in light curves of Be stars during their outburst phases.

Finally we draw attention to an increase in the emission of the Hα line that occurred at about the time the FUV ringing started. This increased emission hints that ~50,000K plasma near the star's surface can influence the circumstellar disc at ~12R_* by its increased Lyman continuum flux.

Accepted by Ap J 97 May 20

Preprints from `MSMITH@iuegtc.gsfc.nasa.gov`

Non-LTE Line-Blanketed Model Atmospheres of Hot Stars. III. Hot Subdwarfs: The sdO Star, BD +75° 325

Thierry Lanz[1,2], **Ivan Hubeny**[1], **& Sara R. Heap**[1]

[1] Laboratory for Astronomy and Solar Physics, NASA Goddard Space Flight Center, Greenbelt, MD 20771

[2] Sterrenkundig Instituut, Utrecht University, NL-3508 TA Utrecht, The Netherlands

We have made a detailed comparison of results of spectroscopic analysis using three differents types of model atmospheres: classical non-LTE H-He models; approximate non-LTE line-blanketed models (with only a subset of Fe and Ni lines, those originating from transitions between levels with measured energies), and non-LTE fully blanketed models. The three models were applied to the sdO star, BD +75° 325, adopted as a test case. We demonstrate that the effects of line blanketing are very important: the best fit of the observed H and He lines is achieved for $T_{\rm eff}$ = 58,000 K when using H-He models, $T_{\rm eff}$ = 55,000 K for approximate non-LTE line-blanketed models, and $T_{\rm eff}$ = 52,000 K, for fully blanketed non-LTE models.

Using the high-resolution GHRS spectrum of BD +75° 325, and our final fully blanketed model, we have derived reliable abundances of He, C, N, O, Si, Fe, and Ni. We find that BD +75° 325 is a He-enriched star (He/H = 1 by number), whose surface exhibits CNO-cycle products, i.e. N-rich ($A_{\rm N} = 1.5 \times 10^{-3}$ by number, or 4.2×10^{-3} by mass fraction), and C- and O-deficient (by factor of about 100 with respect to the solar value). We also find a significant surface depletion of silicon and an enhancement of iron and nickel. We argue that these anomalous abundances reflect some mixing with processed material from the core, with subsequent modification at the surface by diffusion processes. Finally, BD +75° 325 possesses a weak wind. Using a simplified description of the wind, we have derived a preliminary value of the mass loss rate, $\dot{M} = 1.5 \times 10^{-11} M_{\odot}$/yr.

Accepted by *Astrophysical Journal*
Preprints from `lanz@fys.ruu.nl`
or by anonymous ftp to `ruunat.fys.ruu.nl/pub/astronomy/lanz` *file:* `bd_revpp.ps.gz`
or on the web at `http://www.fys.ruu.nl/~lanz/preprints.html`

Submitted Papers

The Luminous Eclipsing SMC OB + WN Binary HD 5980 Before and During the Recent LBV-Like Outburst: An Extreme Case of Colliding Winds

A.F.J. Moffat[1,2,3], **S.V. Marchenko**[1,4], **P. Bartzakos**[1,3], **V.S. Niemela**[5,6,3], **M.A. Cerruti**[5,7,3], **A.M. Magalhaes**[8], **L. Balona**[9], **N. St-Louis**[1], **W. Seggewiss**[10,2], **R. Lamontagne**[1]

[1] Département de Physique, Université de Montréal, C.P. 6128, Succ. Centre-Ville, Montréal, QC, H3C 3J7, Canada, and Observatoire du mont Mégantic

[2] Visiting Astronomer, Max Planck Institut für Astronomie 2.2m telescope, La Silla, Chile

[3] Visiting Astronomer, CASLEO, operated under agreement between CONICET, SeCyt, and the Universities of La Plata, Córdoba and San Juan, Argentina

[4] Visiting Astronomer, Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatories, operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National

Science Foundation
[5] Facultad de Ciencias Astronónicas y Geofísicas, Universidad Nacional de La Plata, 1900 La Plata, Argentina
[6] Member of the Carrera del Investigador Científico, CIC, Prov. de Buenos Aires, Argentina
[7] Member of the Carrera del Investigador Científico, CONICET, Argentina
[8] Inst. Astron. e Geofisico, Univ. de Sao Paulo, Caixa Postal 9638, 01065-970 Sao Paulo, SP, Brazil
[9] South African Astronomical Observatory, P.O. Box 9, Observatory 7935, Cape Town, South Africa
[10] Observatorium Hoher List der Universitätssternwarte Bonn, D-54550 Daun, Germany

The 1994 LBV-like outburst of one of the luminous, hot components of the binary HD 5980 made it the brightest star in the SMC for an interval of 5 months. The most intriguing question to arise in this event is: Why did HD 5980 change from an H-poor WN3 spectrum with veiled OB absorption lines about 20 years ago, to an H-rich WN11 spectrum without central absorption lines during the outburst? In an attempt to answer this enigma, we present and analyze new phase-dependent spectroscopic, polarimetric and light-curve observations. Together with other published data, these new observations allow us to considerably improve the orbital parameters, except for the radial velocity amplitudes and hence the masses, which are only roughly constrained.

Especially important in HD 5980 is the strong collision of the two nearly equal pre-outburst winds. The emission-line spectrum generated by the collision tends to mask the underlying line spectra of both components when the system is relatively quiescent. We argue that the pre-erupting system consists of a very luminous but moderately massive, H-rich O-type supergiant, possibly with emission lines, and a low-mass, H-poor, relatively faint WN companion, whose lines are mostly drowned out by wind collision emission, the spectrum of which largely imitates that of a WNE star. It was the O supergiant that erupted in a normal way as an H-rich, visually bright WN11 star. In this way, the need for peculiar evolutionary scenarios (e.g. rapidly from a faint, low-mass, H-poor WNE star to a luminous, H-rich WNL star) is avoided.

Submitted to the Astrophysical Journal
Preprints from `moffat@astro.umontreal.ca`

In Proceedings

Stellar Physics and Starburst Evolution

Georges Meynet

Geneva Observatory, CH-1290 Sauverny, Switzerland

Starbursts regions offer a very interesting opportunity to study the links between stellar and galactic evolutions. Indeed starburst triggering is often related to dynamical processes. For instance, the most spectacular starbursts occur in tidally interacting galaxies and mergers. On the other hand, many observational features of starbursts, as their integrated luminosity, colors, spectral evolution, depend on stellar physics. In these lectures, we shall concentrate on this second aspect, trying to give some elements of response to the following question: how the photometric and chemical evolution of starburst regions depends on stellar physics ?

The lectures are organized as follows: in section 2, we recall some basic principles governing stellar evolution as well as the evolutionary scenarios followed by stars of different initial masses. We also describe the main physical ingredients incorporated into stellar models. The section 3 is devoted to the presentation of observational tests of stellar models. This step is a necessary prerequisite in order to assess the performances as well as the limitations of the stellar models, further used as an ingredient of population syntheses models. The impact of some physical ingredients of the stellar models on the outputs of populations syntheses models is discussed in section 4. Some aspects of the chemical evolution of starburst regions is presented in section 5. Finally, as a conclusion, we briefly propose some directions of research for future works.

To appear in ***Starbursts: Triggers, Nature and Evolution*****, proceedings of Les Houches summer school organized by B. Guiderdoni and A. Kembhavi**
Preprints from `georges.meynet@obs.unige.ch`

Circumstellar Ring Nebulae around Early B Supergiants

You-Hua Chu[1], Wolfgang Brandner[1], and Eva K. Grebel[2]

[1] Astronomy Department, University of Illinois, 1002 W. Green Street, Urbana, IL 61801

[2] Astronomisches Institut der Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

The rings around SN 1987A were shaped by the B3I progenitor Sk−69 deg and ionized by the UV flash of the supernova. No ring nebulae around B supergiants were known prior to the discovery of SN 1987A's rings. To determine the frequency of ring nebulae around B supergiants and to search for living counterparts of Sk−69 deg, we have made three pilot searches for ring nebulae around B supergiants in the Galaxy, in 30 Doradus, and in the Small Magellanic Cloud. All three searches yielded negative results, confirming that ring nebulae around B supergiants are rarely seen. We have serendipitously found a circumstellar ring around the B1.5I star Sher 25 in the giant H II region NGC 3603 in the Galaxy. The similarities between this ring and SN 1987A's inner ring suggest that Sher 25 is a Galactic counterpart of Sk−69 deg.

To appear in: CTIO/ESO/LCO Workshop *"SN 1987A: 10 Years After"*
For preprints, contact `chu@astro.uiuc.edu`
Also available from the URL `http://www.astro.uiuc.edu/ chu/preprints/BSG.ps`

Thesis Report

Hipparcos contribution to the study of A-type stars in the solar neighborhood. Kinematics and Initial Mass Function.

V. Sabas

DASGAL, URA 335 du CNRS
Observatoire de Paris
Place J. Janssen, 92195 Meudon Cedex, France

The Galactic disk complexity is well traced by kinematical properties and photometrical distributions of young stars. Already in 1963, Eggen showed the existence of kinematical groups. Gómez et al (1990) suggested that they come from starbursts. Their existence allows us to constraint the galactic

mixing time.
To modelize a given stars distribution one needs to know the Initial Mass Function (IMF) and the Stellar Formation Rate (SFR). Until now, a Mass-Luminosity relation was needed, which is very incertain for this type of stars. The Hipparcos astrometric satellite observed 118000 stars on the whole sky during 4 years. The good accuracy of positions, parallaxes and proper motions together with the completness of data allows us to get a new insight into galactical dynamics. We use a B5-F5 stars sample observed by Hipparcos to study the kinematics of hot stars of the solar neighbourhood :
We first describe the acquisition of radial velocities, effective temperatures, absolute magnitude and the determination of masses and ages.

We confirm the existence of Eggen groups and find a range of ages for each of them, giving hints that these groups come from successive clusters formed in one Giant Molecular Cloud. We confirm that the stars are not well mixed after about 10 galactic years. Finally, we estimate the solar motion to be of (11.5, 14.1, 8.6) km/s.
In the last part, we determine the IMF between 1.2 and 4 Msol, assuming a constant SFR. We obtain a slope of 0.94 +/- 0.14, lower than the reference values, but in good agreement with more recent determinations concerning the whole mass range.

Copies from `virginie.sabas@obspm.fr`