THE HOT STAR NEWSLETTER

⋆

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

No. 32 August 1997

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

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

Contents of this newsletter

From the editor

This issue begins with an urgent call for **coordinated observations of η Car**, as one of its puzzling spectroscopic events is expected in a few months. (See the commentary by Kris Davidson *et al.*) A special oral session on η Car is being planned for the January AAS meeting. For details, see the *Meetings* section (at the end of this newsletter), where you will also find the preliminary announcement of our **1998 Symposium**.

The **Wolf-Rayet bibliography** has been updated by Karel van der Hucht. It can be found on the WWW at `http://www.astro.ugto.mx/∼eenens/hot/` or `http://www.star.ucl.ac.uk/∼hsn/index.html`. This very useful work should serve as a reminder that the newsletter cannot claim to be complete. Indeed a comparison between the bibliography and past issues of the Hot Star Newsletter reveals that many more papers are published than reported in the newsletter. The situation is probably even worse as far as other early stars (OB, Of, LBV) are concerned. An effort will be made to complete the distribution list of the newsletter and to chase missing abstracts. If you notice a paper not publicized in the newsletter please alert the editor.

Commentary

Urgent: The Impending Event in eta Carinae

K. Davidson[1], M. Corcoran[2], and A. Damineli[3,4]

[1] Astronomy Dept., University of Minnesota

[2] Laboratory of High Energy Astrophysics, Goddard Space Flight Center

[3] Inst. Astr. e Geof., Universidade de São Paulo

[4] JILA, University of Colorado

Eta Carinae is expected to undergo an unusual spectroscopic event at the end of this year and the beginning of 1998. Although the precise nature of the event is not yet understood, it is likely to be an unprecedented opportunity to settle certain long-standing major problems regarding this enigmatic object. Unfortunately, there is serious cause for concern that observational coverage of this event, ground-based but especially with HST, will not be adequate. *The situation is so extraordinary that additional observations must be encouraged even though time is now growing short.* In the following notes we provide some background information and solicit help. (A review containing more general references about η Car will appear soon: Davidson & Humphreys 1997, *Ann.Revs.Astr.Ap.,* in press).

The historical development leading up to the predicted event has been as follows. On several occasions in recent decades a particular type of spectroscopic event in η Car has been observed: see, e.g., Zanella et al. 1984, *A&A* 137, 79; Ruiz et al. 1984, *ApJ* 285, L19; Bidelman et al. 1993, *PASP* 105, 785; Damineli et al. 1993, *Space Sci. Revs.* 66, 211. During each event some bright narrow emission lines temporarily change dramatically, especially those of higher excitation. [Ne III], He I λ10830, and the narrow component of Hα, for example, can disappear entirely for several weeks. Most of the narrow-line emission is formed in strange slow-moving blobs of ejecta several hundred a.u. from the star, probably near the equatorial plane (Davidson et al. 1995 and 1997, *AJ* 109, 1784, and 113, 335). Zanella et al. conjectured that the observed type of event signals a temporary decrease in the supply of hard UV photons. Whether this is due to a shell ejection, or geometrical phenomena in a binary system, or other causes (see below), it seems a very promising clue to the nature of Eta and in particular to the basic instability. But the observations were neither intensive nor extensive and the reports tended to be anecdotal, because the events had occurred unexpectedly and were brief in duration.

Last year Damineli (1996, *ApJ* 460, L49) found good evidence that the spectroscopic events recur with a 5.5-year period. All the known examples were consistent with this periodicity, as were some prominent near-infrared photometric fluctuations noted by Whitelock et al. (1994, *MNRAS* 270, 364). If this periodicity is confirmed (and we now expect that it will be), then *it greatly enhances the importance of the spectroscopic events.* They had already seemed useful as noted above; but in addition the probable recurrence period is likely to be of great theoretical significance, while it also enables us to prepare for suitable observations of the next event! *This is predicted to occur near 1998 Jan 1,* definitely within a few months of that date and probably within a few weeks of it. So far, according to Damineli's continuing observations, the He I λ10830 emission line has been fading on schedule during 1997, behaving as it did before the 1992 event. The X-ray behavior has also been peculiar lately, as noted below.

A period of 5.5 years in η Car is a quantitative surprise. If this represents an orbital period in a binary, then the separation between components is far too large for significant interactions except perhaps very near periastron in a high-eccentricity model. In a single-star scenario, 5.5 years is far longer than any obvious dynamical timescale and probably must represent a thermal timescale for some particular fraction of the star. (The mere fact of a well-defined period does not rule out a single-star model; Eta has often been likened to a geyser, a simile consistent with the idea of a thermal timescale, and of course some geysers are fairly periodic.)

Damineli, Conti, and Lopes (1997, *New Astr.* 2, 107) have proposed a specific 5.5-yr binary model based on some apparent changes in radial velocity. Davidson (1997, *New Astr.* to appear soon) suggests a more eccentric orbit but also notes that the binary models have some awkward features, while a single-star shell ejection event may produce a similar "velocity curve". The important points are that the binary–vs.–single-star question is still quite unresolved, and that the basic parameters of either type of model are also unsettled. There is good reason to hope that spectroscopy during and after the predicted event can answer the first question and help a great deal with the second.

Meanwhile, a group led by Corcoran has found remarkable results while monitoring the hard X-rays of η Car. The origin of these X-rays is unknown, especially since they indicate high temperatures requiring shock speeds of 2000 km/s or more, much faster than Eta's wind speed observed at visual wavelengths (see Corcoran et al. 1997, submitted to *ApJ*). Colliding winds in a binary system and fast localized wind streams from a single star are among the possible explanations. Since mid-1996 the hard X-ray flux has been increasing, but the most interesting development is a series of progressively higher peaks ("flares") that recur with a period of 85 days, reported in IAU Circulars 6668 and 6701. Such a period is speculatively fascinating against the background of the longer 5.5-year period, but the main point here is that the rising, pulsating X-ray flux curve informally gives the impression of an impending crisis.

The expected event may therefore give us the best observational opportunity we've ever had to attack several major problems alluded to above: the binary–vs.–single-star question for η Car, the mystery of the star's basic instability, and the origin of two different observed periodicities. But those are not all; other unusual problems may also be included in the list, especially concerning peculiar excitation mechanisms in the narrow-line-gas near Eta. This gas is the most intense known site for certain fluorescent processes reviewed by Johansson & Hamann (1993, *Physica Scripta* T47, 157). Especially noteworthy are the amazingly intense Fe II features near 2507 Å, which may even represent the only known natural UV laser (Johansson et al. 1996, in *Science with the HST, STScI/ST-ECF Workshop,* p. 361). These are expected to be very sensitive to the UV illumination and observations of their behavior in a spectroscopic event are extremely desirable.

At this time only a limited set of observations are scheduled, not nearly as extensive as the event deserves. A group including Damineli will monitor η Car with ground-based spectroscopy at some wavelengths, and Corcoran's group plan to continue their intensive X-ray monitoring; contact us for details. Below we list a few types of observations that may prove valuable or even essential; interested observers may devise alternative approaches. Needed are:

(1) Coverage at other wavelength ranges, especially radio and mm-wave, during the event and in the following months.

(2) Additional ground-based spectroscopy. There are two obvious aspects to watch for, the intensity

behavior of the narrow emission lines with various excitations and also the velocity behavior of the broad lines that come from the star itself.

(3) Precisely repetitive large-telescope long-slit spectroscopy of the homunculus nebula during the weeks and months following the event. Since the homunculus is essentially a scattering nebula about half a lightyear across, reflected spectrum changes may be detectable after suitable delay times. If detectable, these would give information about the appearance of the event in various directions. We must acknowledge that such observations are expected to be difficult.

(4) Repeated large-telescope imaging for photometric purposes. Photometric changes are not expected to be dramatic, but it would be prudent to have some careful data "just in case". Emission-line photometry of the hydrogen lines may prove useful.

(5) HST/STIS observations with very high spatial resolution. These are needed for at least two reasons. First, the spectrum of the star itself must be spatially resolved in order to reliably test the predicted orbital velocity changes for binary models. Second, in some models the changes in the narrow emission lines should move across a region about 0.3 arcsec across, for example due to shadowing in a binary scenario. (This region is described in Davidson et al. 1997, *AJ* 113, 334, and refs. therein.) Such observations would of course represent a *tour de force* of HST spectroscopy, but they seem attainable.

(6) HST/STIS observations in the UV, again with at least two different specific motivations. First, the spectral changes in the star itself are expected to be far more noticeable in the UV; in a binary model that is the only likely wavelength region for detecting the partial eclipse of the companion star as it moves behind the primary's dense wind. Second, it would be extremely disappointing to allow the bizarre Fe II λ2507 emission (mentioned above) to go unobserved during such an event.

It is frustrating to report that *no* HST observations of the impending event have been approved at this time. More than once we have requested emergency target-of-opportunity STIS observations of the event, emphasizing the extraordinariness of the situation and suggesting that such data should become public as soon as they are obtained. Surprisingly, STScI has denied all these requests; but we hope they may yet be persuaded to reconsider. In our opinion, considering the unique nature of the event and the unique nature of η Car, a failure to obtain UV spectroscopy and high-spatial-resolution data would constitute a significant and unnecessary Missed Opportunity for stellar and nebular astrophysics.

In summary, we welcome and solicit community interest and participation in the expected event, and we hope to organize expressions of support for adequate observations. Time is short; please mention the situation to your colleagues, and for further information contact us.

Contact: `kd@ea.spa.umn.edu`,
`corcoran@barnegat.gsfc.nasa.gov`,
`damineli@casa.colorado.edu`

Accepted Papers

The Young Massive Stellar Objects of M17

M.M.Hanson[1], I.D.Howarth [2] & P.S.Conti[3]

[1] Steward Observatory, University of Arizona, Tucson, AZ, 85721, USA

[2] Department of Physics & Astronomy, University College London, Gower Street, London, WC1E 6BT, UK

[3] JILA, University of Colorado, Boulder, CO 80309, USA

We present a multi-wavelength spectroscopic survey which reveals the ionizing cluster of M17, and uncovers a population of young stellar objects (YSOs) of high mass ($M \sim 5-20 M_\odot$). The masses of the stars have been determined fairly accurately through optical or near-infrared spectral classification. We find strong circumstantial evidence for disks around the massive YSOs in the following forms: near-infrared excess, optical veiling, CO bandhead emission, and/or Paδ emission. We find a direct correlation between those YSOs which show CO bandhead emission at 2.3 μm and those stars in our survey that show Paδ emission; in three of the four Paδ emission stars this line is double peaked (suggestive of a bi-polar wind or a rotating disk or envelope). Our data suggest that circumstellar material, possibly in the form of a disk, is prevalent among very young objects of fairly high mass. Based on considerations of disk lifetimes in other young clusters, the M17 cluster appears to be very young, perhaps less than 1 Myr.

We have also identified at least nine O stars and a couple of late-O/early-B stars, most behind more than 8 magnitudes of visible extinction using either optical or near-infrared spectral types. Several stars have inferred masses in excess of $60 M_\odot$ and they look to be very close to the predicted zero-age main-sequence with an estimated age of about 1 Myr, consistent with the age of the massive YSOs in the cluster. We have used the O stars to determine the distance to M17 which assumes the stars to lie on the zero-age main sequence (1300^{+400}_{-200} pc). While we attempt to determine an IMF for the cluster, it is incomplete even at high masses due to regions of extremely high extinction ($A_V > 20$) in the cluster. We have also used the M17 O stars to study the dust properties in the local cloud and the behavior of the diffuse interstellar bands (DIBS) along this sight line, over the extinction range, $A_V = 3 - 10$. The DIBS over this extinction range show little change in spectral shape nor a significant increase in strength. We suggest the features are already saturated at small A_V, or the material local to M17, where the increased extinction is being traced, does not contain the carriers of the DIB feature.

Accepted by *The Astrophysical Journal*, Nov. 10, 1997 issue
Preprints from `mhanson@as.arizona.edu`

On the variable spectrum of HD 45677 (FS CMa)

G.Israelian[1] and F.Musaev[2]

[1] Insituto de Astrofisica de Canarias, E-38200 La Laguna, Tenerife, Spain

[2] Special Astrophysical Observatory of the Russian AS, Nizhnij Arkhyz 357147, Russia

We have studied high-resolution optical spectra of the peculiar B[e] star HD 45677 (FS CMa) observed during 3 nights in October 1995. The main results of our analysis can be summarized as follows: (1) The complex and variable profiles of Hβ indicate the presence of matter outflow. Three blue-shifted

absorption components have been detected. (2) The inverse P Cygni red-shifted profiles have been observed in the Mg II 4481 Å line indicating the infall of cool gas onto the star. (3) These observations confirm our previous estimate (Israelian et al. 1996) for the projected rotational velocity of the order of 70 km s^{-1}. (4) Accreting gas collides with the atmosphere and/or inner disk material producing the so-called *filling in by emission* effect and/or extended red wings of He I 5876 Å line.

Accepted by Astron.Astrophys.
Preprints from gil@iac.es

Star Formation in R136: A Cluster of O3 Stars Revealed by Hubble Space Telescope Spectroscopy

Philip Massey[1] Deidre A. Hunter[2]

[1] KPNO/NOAO, P.O. 26732, Tucson, AZ 85726-6732

[2] Lowell Observatory, 1400 Mars Hill Road, Flagstaff, AZ 86001

The R136 cluster in 30 Doradus is the prototype "super star cluster", and the only example sufficiently close that its massive star content can be studied directly. We have used *Hubble Space Telescope* to obtain spectra of 65 of the bluest, most luminous stars in R136, and find that the majority of these stars are of type O3, the hottest, most luminous and massive stars known. The total number of O3 stars in this one cluster exceed the total number known elsewhere in the Milky Way or Magellanic Clouds. The highest luminosity stars found are O3 If*, O4 If+, O3 If/WN6-A, and H-rich WN stars, with masses in excess of 120 $\mathcal{M}_\odot$, the highest masses for which appropriate evolutionary tracks are currently available. In accord with de Koter, Heap, & Hubeny, we conclude that these WN stars must be core-H burning stars whose spectra are WR-like due to high luminosity, and we find that their individual luminosities are a factor of 10 higher than normal WN stars of similar type, but like those found in the Galactic cluster NGC 3603, which they also resemble spectroscopically. Our spectroscopy does include stars as late as B0 V, and samples most stars in the core of the R136 cluster with masses $> 50\mathcal{M}_\odot$. The spectroscopy has been combined with *HST* photometry to study the star formation history and initial mass function of the R136 cluster. The young age ($< 1-2$ Myr) for the highest mass stars, combined with what was previously known for the intermediate-mass populations, suggests that the lower mass stars began forming 4-5 Myr ago, and continued until the high mass stars formed, consistent with the paradigm in which the formation of massive stars shuts down further star formation in the molecular cloud. Despite the unique preponderance of the highest mass and luminosity stars ever seen, the IMF is found to be completely normal, with a slope $\Gamma = -1.3$ to -1.4. The number of high mass stars is in good accord with that predicted by the IMF of the intermediate-mass stars, suggesting that a Salpeter-like IMF holds over the mass range 2.8 $\mathcal{M}_\odot$ to 120 $\mathcal{M}_\odot$ within the R136 cluster. The fact that the IMF slope in R136 is indistinguishable from those of Galactic and Magellanic Cloud OB associations suggests that star formation produces the same distribution of masses over a range of $\sim 200\times$ in stellar density, from that of sparse OB associations to that typical of globular clusters. The large number of O3 stars in R136 is then simply a consequence of its youth ($< 1-2$ Myr) and its richness, suggesting that the upper mass "cutoff" to the IMF seen in OB associations may simply be the result of their sparcity.

Accepted by ApJ
Preprints from massey@noao.edu
or by anonymous ftp to tofu.noao.edu, cd pub, get r136.ps

The effect of radiation pressure on equipotential surfaces in binary systems

Ian D. Howarth[1]

[1] Dept. Physics & Astronomy, University College London, Gower St., London WC1E 6BT, UK

The effect of radiation pressure on surface equipotentials is reviewed, with particular attention to binary systems. For centrally condensed stars obeying von Zeipel's law, it is shown that the shapes and limiting volumes are *unchanged* by radiation pressure if the companion's radiation has no important effect.

Accepted by The Observatory

Preprints from idh@star.ucl.ac.uk
or by anonymous ftp to star.ucl.ac.uk, cd /pub/idh/pot
or on the web at http://www.star.ucl.ac.uk/ idh/HSG/HSG/PUBLS.html

HST/GHRS Observations of the Be + sdO Binary Phi Persei

Douglas R. Gies[1], **William G. Bagnuolo, Jr.**[1], **Elizabeth C. Ferrara**[1], **Anthony B. Kaye**[1], **Michelle L. Thaller**[1], **Laura R. Penny**[2], **and Geraldine J. Peters**[3]

[1] Center for High Angular Resolution Astronomy and Department of Physics and Astronomy, Georgia State University, Atlanta, GA 30303

[2] Department of Physics, University of Montreal, C.P. 6128, Succ. Centre Ville, Montreal, PQ H3C 3J7, Canada

[3] Space Sciences Center, University of Southern California, University Park, Los Angeles, CA 90089-1341

Mass transfer during the evolution of intermediate-mass stars in a close binary system can result in a rejuvenated and spun-up secondary star (which may appear as a rapidly rotating Be star) orbiting an unseen, stripped-down, remnant companion. One of the best candidates for such a system is the long period (127 d) binary, ϕ Per. Here we present new HST/GHRS spectra of ϕ Per in several UV regions that show clearly for the first time the spectral signature of the faint remnant companion. We derive a double-lined solution for the radial velocity curve which yields masses of $9.3 \pm 0.3\ M_{\odot}$ and $1.14 \pm 0.04\ M_{\odot}$ for the Be star and companion, respectively. A Doppler tomographic reconstruction of the secondary spectrum shows a rich spectrum dominated by sharp Fe 4 and Fe 5 lines, similar to those observed in hot sdO stars. NLTE spectrum synthesis indicates the subdwarf has a temperature, $T_{\rm eff} = 53 \pm 3$ kK, and gravity, $\log g = 4.2 \pm 0.1$, and that the subdwarf to Be star flux ratio is 0.165 ± 0.006 and 0.154 ± 0.009 for the 1374 Å and 1647 Å regions, respectively. The spectrum of the Be primary appears normal for a very rapidly rotating early B-type star, but we argue that the star is overluminous for its mass (perhaps due to accretion induced mixing). Additional sharp lines of Fe 4 appear when the companion is in the foreground, and we show that these form in a heated region of the Be star's disk that faces the hot subdwarf.

Accepted by ApJ

Preprints from gies@cghara.gsu.edu
or by anonymous ftp to chara.gsu.edu [Gies/pp.ps]

The rejuvenation of starburst regions due to massive close binary evolution

J. Van Bever[1] and D. Vanbeveren[2]

[1] Astrophysical Institute Vrije Universiteit Brussel Pleinlaan 2 B-1050 Brussels Belgium

We present the results of population number synthesis calculations on young starbursts in regions of solar metallicity, using a Monte Carlo simulation of bursts containing 1000 stellar objects. They clearly show that one has to account for interacting binaries to get a correct image of these regions. Independently of all sorts of distributions such as initial mass function or mass ratio distribution, interacting binary evolution makes starbursts look younger than they really are. What happens is that after some time, the area of the main sequence above the actual turnoff point of the HR diagram gets crowded with accretion stars, which are part of the end product of mass transfer in close binaries. Shortly after their appearence, these accretion stars begin to dominate the O star population in a starburst, proceeding to the moment where they are the only ones left (since at that particular stage, all single and unevolved binary O stars have disappeared). As a consequence, if it is assumed that the entire population are single stars, or that the features of the starburst are solely due to single star evolution, the resulting age estimation of the starburst is wrong, i.e. the starburst may be considerably older than it appears.

Accepted by A.A. *Preprints from* `wvanrens@vub.ac.be`

Dynamical evolution of wind-driven HII regions in strong density gradients.

F. Comerón

European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching bei München, Germany

The champagne model which describes the dynamical evolution of HII regions in the presence of a density discontinuity is reexamined including the effects of stellar winds. We consider stars with widely different ratios of ionizing flux to stellar wind power, as well as different distances between the star and the boundary of its parental molecular cloud. We also performed simulations with reduced cooling by suppressing thermal conduction. The evolution of the gas is followed by means of axisymmetric 2-D numerical simulations.

The hot gas generated by a shocked stellar wind produces important morphological differences with respect to the windless case: the basic one is that the dense shell of swept-up gas which surrounds the bubble of hot gas reaches velocities much higher than those of the outer boundary of the champagne flow in the windless case, and the volume affected by the blowout of the HII region is accordingly much greater. Instabilities in the expanding shell are likely to make the density and velocity structure of the HII region more complex.

Simulated maps of X-ray emission produced by the shocked stellar wind are presented and discussed. X-ray emission has a compact and an extended peak, both in intensity and in hardness ratio, arising from the different shock structures present inside the hot bubble. We also present maps of low frequency emission, with emphasis on the continuum emission as a tracer of emission measure and on the line-to-continuum ratio at a given frequency as a tracer of kinematic structure.

Accepted by Astronomy and Astrophysics *Preprints from* `fcomeron@eso.org`

Hipparcos, VLA, and CCD Observations of Cyg OB2 No. 5: Solving the Mystery of the Radio "Companion"

M.E. Contreras[1], L.F. Rodríguez[1],
M. Tapia[2,3], D. Cardini[4], A. Emanuele[4], M. Badiali[4], and P. Persi[4]

[1] Instituto de Astronomía, UNAM, Apdo. Postal 70-264, 04510 México, D.F., México

[2] Instituto de Astronomía, UNAM, Apdo. Postal 877, Ensenada, México

[3] Royal Greenwich Observatory, Madingley Road, Cambridge, England

[4] Istituto Astrofisica Spaziale, CNR, C.P. 67, 00044 Frascati, Italy

We present accurate optical and radio astrometry for the unresolved contact binary system Cyg OB2 No. 5 and its weaker component to the northeast. While the radio and optical positions of the primary component (taken to be the unresolved contact binary) agree within observational error (∼70 mas), we find that the weaker radio component does not agree in position with the second optical component of the system, but falls in between the two optical components. We conclude that the weaker radio component of this system is not associated with the secondary star but appears to be synchrotron emission produced at the shock interaction zone between the winds of the stars. Differential B and V band CCD and Hipparcos photometry was used to derive the approximate spectral type (B0V-B2V) of the secondary. Ram pressure arguments in the colliding-wind model give a mass loss rate for the secondary star consistent with the expected one, considering the earliest spectral type.

Accepted by The Astrophysical Journal (Letters)
Preprints on the web at `http://genesis.astrosmo.unam.mx/∼luisfr/`

Is Eta Carinae a Long-Period Binary?

K. Davidson[1]

[1] Astronomy Dept., University of Minnesota, 116 Church St. SE, Minneapolis, MN 55455, USA

Damineli, Conti, and Lopes have recently proposed a specific binary model for η Carinae. It is based on wavelength shifts in hydrogen and helium emission lines, and may explain a 5.5-year periodicity involving spectroscopic events. Here I amplify but also modify their discussion with the following points: (1) A more eccentric orbit gives a better fit to the velocities quoted by those authors. The higher eccentricity implies appreciably different behavior near periastron. (2) Intra-system eclipses may explain the 5.5-year spectroscopic events in a way that is different from the Damineli et al. scenario. (3) On the other hand, a 5.5-year binary model entails several implausibilities; a single-star model seems equally promising at this time. (4) Finally, I list a few specific, possibly decisive observations that can be made during the next critical "event", which is expected to occur around the end of 1997. *These and other observations of the event urgently merit detailed and intensive efforts.*

Accepted by New Astronomy
`http://pigeon.elsevier.nl/journals/newast/Menu.html`
or `http://www.elsevier.com/journals/newast`

Submitted Papers

A Comprehensive Variability Study of the Enigmatic WN8 Stars: Final Results

S.V. Marchenko[1], A.F.J. Moffat[1], T. Eversberg[1], G.M. Hill[1,2], G.H. Tovmassian[3], T. Morel[1] and W. Seggewiss[4]

[1] Département de physique, Université de Montréal, C.P. 6128, Succursale Centre-Ville, Montréal, Québec, H3C 3J7, Canada, and Observatoire du mont Mégantic. E-mail: sergey,moffat,eversber,morel@astro.umontreal.ca

[2] Dominion Astrophysical Observatory, 5071 W. Saanich Road, Victoria,BC, V8X4M6, Canada. E-mail: ghill@dao.nrc.ca

[3] Instituto de Astronomía, Apartado Postal 877, C.P. 22860, Ensenada, México. E-mail: gag@bufadora.astrosen.unam.mx

[4] Universitäts-Sternwarte Bonn, Auf dem Hügel 71, D-53121, Bonn, Germany. E-mail: seggewis@astro.uni-bonn.de

As a conclusion of our all-sky variability survey of the 'enigmatic' variable WN8 stars, we have carried out coordinated multi-site photometric and spectroscopic observations of WN8 stars in 1989 and 1994-1995. We confirm the leading rôle of the stellar core in restructuring the whole wind. This emerges as a *statistical* trend: the higher the level of the ∼continuum (i.e. ∼core) light variations, the higher the variability of the P Cygni edges of the optical emission lines. However, the form of the correlation between the light and profile variations is generally different for each individual star. The high level of activity of WN8 stars may be supported/induced by pulsational instability.

Submitted to MNRAS
Preprints from `sergey@astro.umontreal.ca`

Time-dependent structure in UV absorption lines of the rapid rotators HD 64760 (B0 Ib) and HD 93521 (O9.5 V)

Ian D. Howarth,[1] R.H.D. Townsend,[1] M.J. Clayton,[1] A.W. Fullerton,[2] D.R. Gies,[3] D. Massa,[4] R.K. Prinja[1] & A.H.N. Reid[1]

[1]Department of Physics & Astronomy, University College London, Gower St., London WC1E 6BT

[2]Universitäts-Sternwarte München, Scheinerstrasse 1, D-81679 München, Germany

[3]Center for High Angular Resolution Astronomy, Georgia State University, Atlanta, GA 30303, USA

[4]Hughes STX, 7701 Greenbelt Road, Greenbelt, MD20770, USA

Cross-correlation provides an effective averaging function for spectra containing many line features, a result which can be exploited in order to perform time-series and spatial-domain analyses of absorption-line variability in data of (relatively) poor quality. We apply this method to high-resolution IUE spectra. For the known non-radial pulsator HD 93521 (O9.5 V), time-series analysis recovers two periods which are confirmed in independent optical data ($P_1 = 1.77$ hr, $P_2 = 2.90$ hr); there is no statistically significant excess power at these frequencies in lines formed in the stellar wind. By comparing phase information from the time-series analysis with results from pulsation models, and adopting $v_e \sin i = 432$ km s^{-1}, we estimate $\ell \simeq 10\pm1$ and 6 ± 1 as the harmonic degrees for P_1 and P_2, respectively, with $\ell + m \lesssim 2$ for each mode (where m is the azimuthal order of the mode).

We present evidence for absorption-line variability in HD 64760 (B0.5 Ib), finding marginally significant signals with $P_1 = 8.9$ hr (or, possibly, 14.2 hr) and $P_2 = 29$ hr. The longer period is also present, with

a strong signal, in wind-formed lines. We consider possible circumstellar and (quasi-)photospheric origins for P_2, and conclude that this signal probably does not arise from rotational modulation (with the corollary that the stellar-wind signal also does not arise in corotating structures, contrary to previous suggestions). The phase behaviour of the signals is consistent with non-radial pulsation models characterized by $\ell = 5\pm1$ (P_1) and 2 ± 1 (P_2), with $\ell + m \leq 1$; the wind modulation at P_2 may then result from leakage of pulsation energy into the supersonic outflow. The lack of significant photometric variability is a serious difficulty for this model (any sinusoidal photometric variability at P_2 has semiamplitude < 2.9 mmag at $\lambda_{\rm eff} = 1575$Å, with 95% confidence), but this may itself be a consequence of wave leakage.

Submitted to MNRAS
Preprints from `idh@star.ucl.ac.uk`
or by anonymous ftp to `star.ucl.ac.uk, cd /pub/idh/cma`
or on the web at `http://www.star.ucl.ac.uk/~idh/HSG/HSG/PUBLS.html`

A Multi-Wavelength Campaign on γ Cas. I. The Case for Surface X-Ray Flaring

Myron A. Smith[1], Richard D. Robinson[2], and Robin H. D. Corbet[3]

[1]CSC/IUE Observatory, Sciences Programs, Computer Sciences Corp. 10000A Aerospace Rd., Lanham, MD 20706; msmith@nobel.gsfc.nasa.gov
[2] CSC/STIS LASP, Goddard Space Flight Center
[3] USRA, HEASARC Goddard Space Flight Center

We have obtained simultaneous *RXTE*/PCA and HST/GHRS light curves for the B0.5e star γ Cas in order to compare its X-ray and ultraviolet continuum flux behaviors. The GHRS dataset consisted of a nearly continuous time sequence of UV spectra covering a 21+ hour interval. Each 40 Å spectrum was centered on the Si IV $\lambda\lambda$1394–1403 lines and registered 8100 counts in each 1 s exposure. Combining spectra and integrating over >100 continuum pixels allowed us to define a UV continuum light curve binned to 1 minute with an S/N ratio of a few thousand pix^{-1}. We found that the light curve exhibited variations over a time comparable to the rotation period of the star, showing two broad minima 10 hours apart and having depths of 0.8% and 1.8%. The long-term trends in the UV are anti-correlated with the X-ray fluxes, with the X-rays exhibiting increases of ~10% and ~40% during times of UV flux minima. The stability of the long-term X-ray variations on γ Cas has been confirmed by phasing our March data with contemporaneous *ASCA* data. This gives an X-ray modulation period very close to an estimate of 1.123 days we obtain from phasing the *GHRS* continuum flux curve with an *IUE* light curve from two months earler. We take this as an estimate of the star's rotational period.

The X-ray emission from γ Cas consists of two components. The first is a slowly varying "basal" flux representing the minimum level seen during any given phase. Superimposed on this are rapid fluctuations ("shots") which have lifetimes ranging from < 10 s to ≥10 minutes. The character of these components varies from orbit to orbit, indicating that the emissions are not produced in a "stationary," truly chaotic environment. Moreover, both the number and amplitude of the shots increase as the UV flux decreases. The shot profiles are typically symmetric and can have decay times of a few seconds or less. The shots also have a slightly harder flux distribution than the basal component, suggesting that the two emission regions are not cospatial. The X-ray spectrum indicates a quasi-temperature of $\sim10^8$ K, in agreement with earlier studies.

We present a picture in which the observed UV continuum variations result from the presence of

magnetically-generated structures on or over the star's surface. These features are probably associated with both the basal and shot component, which we model as flare-like events arising within the photosphere. The energies and luminosities of the flares are very strong. For example, the luminosities of even the weakest events in our sample are comparable in strength to the most luminous flares found on cool active stars. Using simple plasma cooling arguments, we find that the source region for the shots has a size scale of $\leq 10^4$ km and densities of $\sim 10^{14}$ cm^{-3}. Typically, only a small fraction of the energy is radiated during a shot event; the remainder fills a surrounding confined volume, perhaps a loop. The heating resulting from many such shots powers basal emission. The loops have a characteristic density of $\leq 10^{11}$ cm^{-3} and scale length of $\geq$0.1R*. This interpretation raises several theoretical questions, such as: how can complex, dymamic fields exist on a star which does not have a convective envelope?, and can how flares occur in a plasma with T $\sim$10^8 K and $N_e \sim 10^{14}$ cm^{-3}?

These results suggest that γ Cas is a member of an arguably new group of hot stars which flare continuously. This group may represent an extension of the Si- and He-anomalous Bp stars to high values of rotation.

Submitted to The Astrophysical Journal
Preprints from msmith@iuegtc.gsfc.nasa.gov
or by anonymous ftp to nobel.gsfc.nasa.govpubGAMMACAS

In Proceedings

Infrared observations of high-mass X-ray binaries

L. Kaper[1], N.R. Trams[2], P. Barr[2], J.Th. van Loon[3], L.B.F.M. Waters[3]

[1] European Southern Observatory, Karl-Schwarzschild-Str. 2, Garching bei München, Germany

[2] ISO Science Operations, ESA-VILSPA, Madrid, Spain

[3] Astronomical Institute, Univ. of Amsterdam, Netherlands

We present the first results of our ISO program on High-Mass X-ray Binaries (HMXBs). Infrared photometry, obtained at different aspect angles of the systems, is used to investigate the massive star's disrupted stellar wind and the accretion flow towards the compact X-ray source.

Scenarios for massive binary evolution predict that HMXBs receive a large kick velocity during the supernova explosion of the compact star's progenitor. One might, therefore, expect to observe wind bow shocks around these systems such as observed around many OB-runaway stars. Such a wind bow shock has recently been discovered around the system Vela X-1.

To appear in Proc. "ISO's view on stellar evolution", July 1-4, 1997, Noordwijkerhout, Eds. Waters, Waelkens, Van der Hucht
Preprints from lkaper@eso.org

Meetings

Meeting on η Car

A special oral session at the next meeting of the American Astronomical Society (Washington, DC, USA 6-10 January 1998) devoted to recent results on Eta Car is being organized. If you are interested in contributing a paper, please e-mail an abstract to corcoran@barnegat.gsfc.nasa.gov, and include the phrase "please sort with eta car papers" in the special instructions box when the abstract is submitted to the AAS. There is time for approximately 9 oral contributions. Poster papers are ok too! Please make sure to make your preference (oral or poster) known.

Communicated by `Corcoran@barnegat.gsfc.nasa.gov`

IAU Symposium No. 193: Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies

On August 28 the IAU Executive Committee decided on the IAU meeting programme for 1998 (*Siderial Times* 1997, No. 11 (29 August 1997), p. 8). To our pleasure we can announce the formal approval of IAU Symposium No. 193 on *Wolf-Rayet phenomena in massive stars and starburst galaxies*, in a location on the West Coast of Mexico, 3 – 7 November 1998.

Outline of scientific programme:
1. Basic observational properties of WR stars and other hot massive stars.
2. State of the art of model atmospheres for single star evolution of massive stars: wind + atmosphere + interior.
3. Hydrodynamical interaction of WR stars and other hot massive stars with their environment: colliding winds and ring nebulae.
4. The role of WR stars and other hot massive stars in the Galactic Center and in giant H II regions.
5. WR stars and other hot massive stars in starburst galaxies. The case of WR galaxies.
6. Starbursts and their role in the spectral and chemical evolution of galaxies.

Scientific Organizing Committee:
P.S. Conti (USA), M.A. Dopita (Australia), F. Ferrini (Italia), T.M. Heckman (USA), K.A. van der Hucht (chair, the Netherlands), R.D. Joseph (USA), G. Koenigsberger (Mexico), D. Kunth (France), C. Leitherer (USA), A. Maeder (Switzerland), F. Matteucci (Italia), J. Melnick (Chile), A.F.J. Moffat (Canada), W. Schmutz (Switzerland), W.D. Vacca (USA), P.M. Williams (UK), and A.J. Willis (UK).

Local Organizing Committee:
S.J. Arthur (Morelia), E. Brinks (Guanajuato), O. Cardona (Puebla), P.R.J. Eenens (chair, Guanajuato), G. Garcia-Segura (Mexico City), J. Guichard (Puebla), G.Koenigsberger (Mexico City), J.F. Lopez (Mexico City), A. Serrano (Puebla), and M. Tapia (Ensenada).

Contacts:
Karel A. van der Hucht, chair SOC — e-mail: `k.vanderhucht@sron.ruu.nl`
Philippe Eenens, chair LOC — e-mail: `eenens@carina.astro.ugto.mx`

A comprehensive First Announcement will be issued late September 1997.