THE HOT STAR NEWSLETTER

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

No. 38 March 1998

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Contents of this newsletter

The Working Group on Hot Massive Star

During the latest General Assembly (Kyoto, August 1997), the Executive Committee of the IAU has officially approved our Working Group on Hot Massive Stars. The approval was communicated in a letter from the General Secretary dated 1997 December 23. Our Working Group fits within IAU Division IV (Stars). The number of subscribers to the *Hot Star Newsletter* (excluding libraries and amateurs) is now over 400. This gives an estimate of the size of our Working Group.

Tasks of the Working Group

Some of the aims of the Working Group (WG) are:
- promote the study of Hot Massive Stars;
- serve as a link between researchers in the field and disseminate information;
- coordinate observing campaigns;
- foster collaborations and exchange between research groups;
- ensure coordination in the planning of meetings;
- maintain a database on hot massive stars (bibliography, catalogues, etc);
- maintain a list of researchers active in the field;
- liaison with IAU Comissions and other Working Groups.

Most of these aims are achieved in good part through the *Hot Star Newsletter* (which has become a recognized and widely used platform for scientific exchanges on hot massive stars) and the related Web pages. However, these aims are the responsability of everyone in the WG. For example: strengthen our access to HST time and other international facilities; define collaborative projects on new or neglected topics; promote exchanges of students from one hot-star group to another; inform us about new papers, books, campaigns, catalogues, conferences, jobs, etc. We welcome suggestions. Offers of help too.

Structure

The WG is meant as a service to the Hot Massive Star community. We wish to avoid unnecessary bureaucratic formalism, e.g. there are no rules regarding membership in the WG. At present, the only structure is the Organizing Committee (OC), elected by the WG in 1995, and the chairman, elected by the OC. The composition of the OC received the approval of the IAU.

Role of the Organizing Committee

It is the duty of the OC to keep in contact with the president of IAU Division IV, and with other WG's and commissions. For the rest, the OC does not wish to take over the tasks of individuals or institutes. For example, the OC will not launch observing campaigns, but is willing to support any such initiative and give an 'official' seal if seen as desirable. The OC will not organize conferences, but is ready to give a hand.

It would also seem a good idea to centralize information on future conference plans, to help avoid conflicts in the timing of the various proposed meetings. We urge that any plan for meetings of interest to the Hot Massive Star community be communicated to the OC, *well before commitments are made.*

OC meetings

The OC does not plan to meet on a regular basis, but will use convenient opportunities, such as during conferences. The ordinary business will be done by e-mail. Everyone is free to contact each member of the OC. However would anyone want to send a formal request to the OC, they are welcome to do so through the chairman. The chairman will inform and/or consult the members of the OC about any important matter.

The OC:

Joe Cassinelli,
Peter Conti,
Philippe Eenens (chairman),
Catharine Garmany,
Rolf Kudritzki,
Henny Lamers,
Andre Maeder,
Tony Moffat,
Stan Owocki,
Karel van der Hucht.

Observing Campaigns

The eta Carinae Observing Campaign

X-rays:
Continuing observation with the RXTE PCA by M. F. Corcoran et al. shows that the star may be emerging from the x-ray 'low state' that began in early Dec. 1997. During the low state, the PCA count rate in the band 2-10 keV dropped from $\geq$ 70 to 15 PCU counts/s in a period of about 1 month. Recent RXTE observations show that the observed x-ray emission has risen by about a factor of 2 since 1998 Feb. 2. If the rate of increase remains constant, then the x-ray flux from η Car should reach or exceed the previous maximum flux level on May 8. The recent x-ray brightening could also be associated with episodic flaring previously reported (IAUC 6668), since a flare maximum was expected to occur on Mar. 17.

η Carinae was pointed as target-of-opportunity by the BeppoSAX satellite on March 18.1 to 19.2 during egress from the present spectroscopic event. Comparison with the December 1996 BeppoSAX observations has put in evidence a large flux defect between 1.5 and 6 keV indicating that the event was still in act at the highest energy level. The Fe-k line flux appeared slightly weaker. The difference with the 1996 observations can be interpreted as due to a larger amount of absorbing column density (about 3 times larger than in 1996) towards a possibly stable hot component.

Optical:
F. Jablonski (INPE), A. Damineli (IAG/USP) & D. F. Lopes (ON, Brazil) reported on IAUC 6849 that, after the strong fading of the emission lines on early December/97, η Carinae remained on low state for about 40 days. On 19 January, the line [FeII] 715.5nm (low excitation) reached again the same intensity as in November. HeI 667.8 nm line (intermediate excitation) did the same in the following month. The high excitation lines continued to be absent on 8 March and the past observations do not allow a precise prediction of the reappearance of these lines. Based on the 1992 event, we expect that the "spectrocopic event" will end by June.

Optical spectra were secured simultaneously to the BeppoSAX observations by Monica Villada at the 2.15 m telescope of CASLEO (El Leoncito, Argentina) and show fairly intense HeI emission lines in agreement with η Car emerging from the deepest phase of the event.

Radio:
Bob Duncan & Stephen White report that the last 12 hour observation of η Carinae, at wavelengths of 3 and 6 cms, with the Australia Telescope was made on the 24th January 1998, and this was followed by a shorter observation on the 2nd March 1998. The total flux is still falling and at a wavelength of 3 cm had dropped to 0.994 Jy in January. A least-squares sinusoidal fit to the flux curve since 1992 yields a period of 6.54 years and predicts a minimum at year 1999.03. Mathematically the fit is good, but intuitively the lack of data straddling a mimimum, either in 1992 or 1999, justifies caution. The source of the radio emission continues to shrink. Now, most of the radio emission comes from a small volume immediately surrounding the optical star; radio emission from the equatorial 'disk' and outer gas clouds has faded.

Additional information:
`http://lheawww.gsfc.nasa.gov/users/corcoran/eta_car/eta_car.html`
`http://casa.colorado.edu/~damineli/`
`http://www.atnf.csiro.au/~rduncan/`

Accepted Papers

Wolf-Rayet Stars Before and After Hipparcos

Wilhelm Seggewiss[1], Anthony Moffat[2], Karel A. van der Hucht[3] and Sergey V. Marchenko[2]

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The HIPPARCOS mission has provided a homogeneous data base of high precision *astrometric* observations: positions, parallaxes, and proper motions; and high-quality broad-band *photometry*, for 67 Wolf-Rayet (WR) stars, i.e. for the bulk of the Galactic WR stars brighter than $v = 12\,\mathrm{mag}$.
The main results are: (1) HIPPARCOS has discovered two new, close visual WR binaries. (2) The parallax measurement of the brightest known WR star, γ^2 Velorum, gives a surprisingly small distance, leading to remarkable consequences. (3) The HIPPARCOS proper motions reveal that WR stars in general follow the rotation of the Galactic disk, although 8 stars show definite runaway character on account of their large peculiar tangential velocities. (4) About 60% of the observed WR stars show detectable light variations: Besides the known variables, WR stars with irregular as well as long-term variations have been detected. The WC9 star WR121 displays a spectacular R CrB-like light minimum resulting from a dust formation episode.

Accepted by Rev. Mexicana A&A

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Light variations of massive stars (α Cyg variables). XV. The LMC supergiants R 99 (LBV), R 103, R 123 (LBV) and R 128

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VBLUW photometry (Walraven system) of the four variable LMC supergiants R 99, R 103, R 123 and R 128 is analysed, searched for periods and discussed. Based on former and present photometry we conclude that two of the three emission-line objects are undoubtedly active LBVs (R 99 and R 123), although not so spectacular. R 123, like AG Car near minimum brightness, shows a low amplitude S Dor activity with superimposed alpha Cyg-type variations.

Accepted by A & A

Preprints from genderen@strw.leidenuniv.nl

S 266: a ring nebula around a Galactic B[e] supergiant?

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A narrow-band Hα image and high-resolution spectroscopy have been obtained in order to investigate the nature of S 266 and its central star MWC 137. The analysis of the stellar and nebular spectra suggests that MWC 137 is a B[e] supergiant located ≥ 6 kpc away from the Sun and not a Herbig Ae/Be star, as it has been traditionally classified. Moreover, the morphology and other properties of the nebula suggest that S 266 is a ring nebula, probably produced by the interaction of stellar winds with the ambient interstellar medium or unprocessed ejected matter. This result would imply that S 266 is the first ring nebulae around a B[e] supergiant known in the Galaxy.

Accepted by MNRAS

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Ultraviolet Imaging Telescope Observations of the Magellanic Clouds

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We present wide-field far-ultraviolet (FUV: 1300–1800 Å) images of the Large and Small Magellanic Clouds (LMC and SMC). These data were obtained by the *Ultraviolet Imaging Telescope* (*UIT*) during the Astro-1 (1990 December 1–10) and Astro-2 (1995 March 2–18) missions; the images provide an extensive FUV mosaic of the SMC (Cornett et al. 1997) and contain numerous regions in the LMC, covering a wide range of stellar densities and current star formation activity. A total of 47 LMC/Lucke-Hodge (1970) and 37 SMC/Hodge (1985) OB associations are completely or partially included in the observed fields. FUV data can identify the hottest OB stars more easily than optical photometry can, and these stars dominate the ionizing flux, which is correlated to the observed Hα flux of the associated H 2 regions. Of the H 2 regions in the DEM catalog (Davies, Elliott, & Meaburn 1976), the *UIT* fields completely or partially include 102 DEM regions in the LMC and 74 DEM regions in the SMC.

We present a catalog of FUV magnitudes derived from point spread function photometry for 37,333 stars in the LMC (the *UIT* FUV magnitudes for 11,306 stars in the SMC were presented in the paper by Cornett et al. 1997), with a completeness limit of $m_{\rm UV} \approx 15$ mag and a detection limit of $m_{\rm UV} \approx 17.5$. The average uncertainty in the photometry is ~ 0.1 mag. The full catalog with astrometric positions, photometry, and other information is available via the electronic journal as well as other publicly available astronomical data archives.

We divided the catalog into field stars and stars that are in DEM regions. We analyzed each of these two sets of stars independently, comparing the composite UV luminosity function of our data to UV magnitudes derived from stellar evolution and atmosphere models in order to derive the underlying stellar formation parameters. We find a most probable initial mass function slope for the LMC field stars of $\Gamma = -1.80 \pm 0.09$. The statistical significance of this single slope for the LMC field stars is extremely high, though we also find some evidence for a field star initial mass function (IMF) slope of $\Gamma \sim -1.4$, equal to the Salpeter (1955) slope. However, in the case of the stars in the DEM regions (the stars in all the regions were analyzed together as a single group), we find three IMF slopes of roughly equal likelihood: $\Gamma = -1.0$, -1.6, and -2.0.

No typical age for the field stars is found in our data for time periods up to a continuous star formation age of 500 Myr, which is the maximum age consistent with the completeness limit magnitude of the catalog's luminosity function. The best age for the collection of cluster stars was found to be $t_0 = 3.4 \pm 1.9$ Myr; this is consistent with the age expected for a collection of OB stars from many different clusters.

Accepted by: The Astronomical Journal
For preprints, contact `joel@boulder.swri.edu`
Also available from the URL `http://www.boulder.swri.edu/~joel/papers.html`
or by anonymous ftp at `ftp.boulder.swri.edu/pub/joel/uit_mc.ps.gz`

Stellar evolution III: meridional circulation with μ–gradients and non–stationarity

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Models of stellar evolution with rotation are very much needed in order to interpret recent stellar properties, in particular for massive stars. For that we proceed to a detailed investigation of some critical physical processes in rotating stars:

1. The equation expressing the transport of angular momentum by circulation and diffusion is revised to also account for expansion and contraction in non–stationary models.

2. We examine the current expressions for the velocity $U(r)$ of the meridional circulation, also taking into account μ–gradients and horizontal turbulence. We show that there are no "μ–currents" but just meridional currents which can be sizeably influenced by the gradients of mean molecular weight μ. A proper account of the μ–gradients may reduce $U(r)$ by one or two orders of magnitude with respect to current expressions.

3. While the usual expressions for the meridional circulation would predict an infinite velocity at the edge of a radiative and semiconvective zone and an inverted circulation in a semiconvective zone, the present developments give a continuity of the solutions for the circulation.

4. The approximation of a stationary circulation, which is no longer valid after the main–sequence phase, is also removed and the case of a general equation of state is considered. We notice that in the stationary regime the horizontal fluctuations of μ represent some fixed fraction of the vertical μ–gradient. To first order, this fraction is not dependent on rotation, because the building of horizontal fluctuations by the circulation is compensated by the smoothing due to horizontal turbulence.

Accepted by Astronomy and Astrophysics *Preprints from* `andre.maeder@obs.unige.ch`

Evidence for one-armed oscillations in the equatorial disk of ζ Tau from GI2T spectrally resolved interferometry

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We report sub-mas observations of the Be Shell star ζ Tau with the Grand Interféromètre à 2 Télescopes (GI2T) on November '93 and October '94. In '93, the Hα line presented a V/R ratio of 0.57 with a central absorption shell component. On October '94 the Hα line presented a reversed V/R ratio of 1.26 with a shallower absorption component. For both epochs we analysed the amplitude and phase of the fringe signal relative to the local continuum as a function of Doppler-shift across Hα. We clearly resolve the Hα emitting envelope on October '93. We find that the bulge of the emission which occurs around RV=+130 km.s^{-1} has a N-S projected position of 0.7 mas to the South of the continuum source. This value corresponds to a linear separation of 3.6 photospheric radii. For October 94, the same analysis shows that the projected position of this bulge, occuring around RV=-70 km.s^{-1} has moved to 0.5 mas, i.e. 2.6 photospheric radii, North of the continuum source. On account of the opposite V/R values between 93 and 94 and the long term Hα cyclic variability of ζ Tau this apparent motion corresponds to the first interferometric detection of an axi-asymmetric envelope around a Be star that we interpret as direct evidence for a prograde one-armed oscillation of its equatorial disk.

Accepted by Astronomy & Astrophysics, Main Journal, March 1998
Preprints from `vakili@obs-azur.fr`

Submitted Papers

X-ray Evidence for Wind-Wind Collision in the Wolf-Rayet Binary V444 Cygni

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We report the results of three *ASCA* observations of the eclipsing Wolf-Rayet binary V444 Cyg (WN5 + O6). These observations were obtained at orbital phases 0.0, 0.25 and 0.5, with the WN5 star in front at phase 0.0 and the O6 star in front at phase 0.5. Acceptable fits of the X-ray spectra using optically thin plasma models require at least two different temperature components with a soft component at $kT_1 \approx 0.6$ keV and a harder component at $kT_2 \approx 2$ keV. The absorption of the hard component varies with orbital phase and is largest when the WN5 star is in front, whereas the X-ray luminosity of the hard component is at a minimum when the O6 star is in front. The high plasma temperature and variability with orbital phase suggest that the hard-component emission is due to a colliding wind shock between the WN5 and O6 stars, with the shock most likely located near the surface of the O6 star. On the other hand, the soft-component emission at $kT_1 \approx 0.6$ keV has a

nearly constant absorption and X-ray luminosity. The soft-component luminosity is $L_{x,1} = (6 - 11) \times 10^{32}$ ergs s^{-1} (0.2 – 4 keV), implying $L_{x,1}/L_{bol} \sim 10^{-6} - 10^{-7}$. This luminosity ratio and the soft-component temperature are similar to those of single massive stars, leading us to attribute the soft emission to the individual O6 and WN5 components.

Submitted to ApJ

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In Proceedings

Turbulence in Line-Driven Stellar Winds

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Hot, luminous OB stars have strong stellar winds driven by the line-scattering of the star's continuum radiation. This line-driving mechanism is understood to be highly unstable to small-scale perturbations. I review efforts to simulate the nonlinear evolution of this instability using radiation hydrodynamics simulation codes. Because the usual local, Sobolev treatment for the line-force does not apply, a major challenge has been to develop computationally tractable methods for approximating the inherently non-local radiative transfer in the large number of wind-driving lines. Results of 1-D simulations generally show development of a highly compressible, stochastic wind structure dominated by strong reverse shocks and dense shells; these arise from amplification of inward-propagating radiatively-modified acoustic modes with anti-correlated velocity and density. In 2-D and 3-D, linear analysis predicts that lateral variations in velocity should be strongly damped by the "line-drag" effect of the diffuse radiation scattered within the line resonance, suggesting possible suppression of classical Rayleigh-Taylor modes for lateral breakup of wind structure. This motivates current efforts toward 2-D simulation of the nonlinear wind structure. An overall goal is to develop connections with studies of highly compressible turbulent structure in other physical and astrophysical contexts.

To appear in *Interstellar Turbulence*, proceedings of a conference held in Puebla, Mexico, Jan. 1998, P. Franco and A. Carramiñana, eds. (Cambridge University Press)

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