# THE HOT STAR NEWSLETTER

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

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http://webhead.com/∼sergio/hot/
http://www.inaoep.mx/∼eenens/hot/
http://www.star.ucl.ac.uk/∼hsn/index.html



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## Contents of this newsletter



## From the editor

### No IAU symposium on WR phenomena in 1997

During their June meeting, the IAU Executive Committee decided that the Kyoto Assembly was too expensive and the finances of the IAU did not allow to support in 1997 our proposed meeting on "The Wolf-Rayet phenomena in massive stars and starbursts". However the IAU EC would welcome a new proposal for 1998 or later.

### Other meetings

Announcements for two 1997 meetings can be found at the end of this newsletter: on B[e] stars in Paris; on ISO in the Netherlands.

### New "hot" web mirror

Thanks to Ian Howarth, the `Hot Massive Star` WWW pages are now also mirrored on the other side of the Atlantic, at UCL (London). The URL is:

http://www.star.ucl.ac.uk/∼hsn/index.html

News

## AG Car at its Maximum

When we recently plotted up the V lightcurve of the Luminous Blue Variable AG Car using amateur observations from the "Association Francaise des Observateurs d'Etoiles Variables", we noticed that the star had returned to a brightness of around 6th magnitude in 1995. This is a brightness level which is similar to that which AG Car showed at its last visual brightness maximum in 1981-1982. After remaining at a level of V=8 during the mid-80ies, AG Car's visual lightcurve had started to rise in 1991, and now seems to be back at its maximum. In early 1995, the visual brightness was as high as 5.7 mag; toward summer of '95, it had come back down to 6th mag (the end of the dataset). (As an aside, this amateur lightcuve seems to show "periodic" variations on a timescale of a year with an amplitude of around 1 mag in the rise to maximum. Their reality should be checked against independent sets of observations). Although observations of AG Car in visual maximum have been made before, we should nevertheless not pass up the opportunity to monitor AG Car in its current maximum. We wonder whether other readers of the newsletter have more current photometry through 1996, whether AG Car is still in maximum or whether it has started to decline, and whether it would be worth planning any observing campaigns for the upcoming observing season of AG Car.

**R. Schulte-Ladbeck (`rsl@binar.phyast.pitt.edu`) and R. Kurosawa**

Accepted Papers

## An H$\alpha$ outburst in the B emission line star HD 76534

**René D. Oudmaijer and Janet E. Drew**

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We present the discovery of unusually rapid and strong variations in the H$\alpha$ emission line of the emission line star HD 76534. Within two days, a strong emission line changed to photospheric absorption, while the line was in emission only two hours later. The observed timescale is an order of magnitude shorter than has been observed before in Be-type stars.

Two different scenarios that may be able to explain the observed behaviour are explored. The deduced mass loss rates are in agreement with the mass ejection mechanism, that has been invoked to explain the H$\alpha$ outbursts of variable Be stars like $\lambda$ Eri and $\mu$ Cen. The fact however that the H$\alpha$ line profile appears to trace a steady-state circumstellar envelope is not in agreement with the expected variable emission from a disk-like structure which is being built up in a few days.

In this paper, a new hypothesis is brought forward to take into account the sudden increase of H$\alpha$ in HD 76534, a change in the ionizing continuum from the star which ionizes a different fraction of a steady state circumstellar envelope.

**Accepted by A&A** *Preprints from* `r.oudmaijer@ic.ac.uk`

# About the initial mass function and He II emission in young starbursts

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We demonstrate that it is crucial to account for the evolution of the starburst population in order to derive reliable numbers of O stars from integrated spectra for burst ages $t > 2-3$ Myr. In these cases the method of Vacca & Conti (1992) and Vacca (1994) systematically underestimates the number of O stars. Therefore the current WR/O number ratios in Wolf-Rayet (WR) galaxies are overestimated. This questions recent claims about flat IMF slopes ($\alpha \sim 1$–2) in these objects. If the evolution of the burst is properly treated we find that the observations are indeed compatible with a Salpeter IMF, in agreement with earlier studies.

Including recent predictions from non–LTE, line blanketed model atmospheres which account for stellar winds, we synthesize the nebular and WR He II $\lambda$ 4686 emission in young starbursts. For metallicities $1/5\,Z_\odot \leq Z \leq Z_\odot$ we predict a strong nebular He II emission due to a significant fraction of WC stars in early WR phases of the burst. For other metallicities broad WR emission will always dominate the He II emission. Our predictions of the nebular He II intensity agree well with the observations in WR galaxies and an important fraction of the giant H II regions where nebular He II is detected. We propose further observational tests of our result.

**Accepted by ApJ Letters** *Preprints from* `schaerer@stsci.edu`

# Fundamental parameters of Wolf-Rayet stars VI. Large Magellanic Cloud WNL stars

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We present a detailed, quantitative study of late WN (WNL) stars in the LMC, based on new optical spectroscopy (AAT, MSO) and the Hillier (1990) atmospheric model. In a previous paper (Crowther et al. 1995a), we showed that 4 out of the 10 known LMC Ofpe/WN9 stars should be re-classified WN9–10. We now present observations of the remaining stars (except the LBV R127), and show that they are also WNL (WN9–11) stars, with the exception of R99. Our total sample consists of 17 stars, and represents all but one of the single LMC WN6–11 population and allows a direct comparison with the stellar parameters and chemical abundances of Galactic WNL stars (Crowther et al. 1995b; Hamann et al. 1995a). Previously unpublished ultraviolet (*HST*-FOS, *IUE*-HIRES) spectroscopy are presented for a subset of our programme stars.

We find observational evidence for lower metallicities in LMC WNL stars compared to the Galaxy, though this is not reflected in their stellar properties. For Galactic and LMC stars we find: (i) a similar range in temperature and luminosity, in contrast to evolutionary predictions; (ii) comparable wind performance values ($\dot{\mathrm{M}}\, v_\infty /[L/c]$) and hydrogen composition, with a broad correlation between increasing helium content and wind performance number; (iii) a general trend to lower wind velocities at lower stellar temperature, with possibly slower winds for LMC WN9–11 stars. Some 30 Dor

WNL stars show exceptional properties: Brey 89 (HD 38282, WN6h) has the highest luminosity (log $(L/L_{\odot})$∼6.25) and mass-loss rate (log $(\mathrm{M}/(M_{\odot}\,\mathrm{yr}^{-1}))$ ∼−3.6) known for any WR star, while Brey 80 (R135, WN7h) has an enormous wind performance number of 50. The observed physical properties of our sample of LMC WNL stars supports the Crowther et al. (1995c) evolutionary scheme for Galactic stars, in that the most massive O stars, exclusive to 30 Dor, evolve directly to O3 If/WN6 and subsequently WN6–7 stars (e.g. Brey 89), without passing through an intermediate LBV phase. In contrast, lower initial mass stars evolve through a LBV phase, encompassing a WN9–11 stage (e.g. BE294), with WN8 stars being their immediate successors.

**Accepted by A & A**
*Preprints available via anonymous ftp - please contact* pac@star.ucl.ac.uk

# Wind variability of B supergiants: II. The two-component stellar wind of $\gamma$ Arae

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The stellar wind of the rapidly rotating early-B supergiant, $\gamma$ Ara, is studied using time series, high-resolution *IUE* spectroscopy secured over $\sim 6$ days in 1993 March. Results are presented based on an analysis of several line species, including N v, C iv, Si iv, Si iii, C ii, and Al iii. Comparisons of the time-averaged wind line morphology of $\gamma$ Ara to the UV spectra of other OB stars, and to profiles from spherically symmetric wind models, suggest that the wind of $\gamma$ Ara is equatorially enhanced.

Co-existing time variable features are identified at low-velocity (redward of $\sim 750$ km s$^{-1}$) and at higher-speeds extending to $\sim -1500$ km s$^{-1}$. The observed interface between these structures is 'defined' by the appearance of a discrete absorption component which is extremely sharp (in velocity space). The central velocity of this 'Super DAC' changes only gradually, over several days, between $\sim -400$ and $-750$ km s$^{-1}$ in most of the ions. However, its location is shifted redward by almost 400 km s$^{-1}$ in Al iii and C ii, indicating that the physical structure giving rise to this feature has a substantial velocity and ionization jump. Constraints on the relative ionization properties of the wind structures are discussed. The overall wind activity in $\gamma$ Ara exhibits a clear ion dependence, such that low-speed features are promoted in low-ionization species, including Al iii, C ii, and Si iii. We also highlight that – in contrast to most OB stars – there are substantial differences in the epoch-to-epoch time-averaged wind profiles of $\gamma$ Ara and that the high-speed component observed during our 1993 time series is normally not present.

We discuss the potential roles of the radiative bi-stability mechanism and wind compressed regions due to rapid stellar rotation for providing gross wind distortions in $\gamma$ Ara.

**Accepted by A&A** *Preprints from* rkp@star.ucl.ac.uk

## The ROSAT all-sky survey catalogue of optically bright OB-type stars

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For the detailed statistical analysis of the X-ray emission of hot stars we selected all stars of spectral type O and B listed in the Yale Bright Star Catalogue and searched for them in the ROSAT All-Sky Survey. In this paper we describe the selection and preparation of the data and present a compilation of the derived X-ray data for a complete sample of bright OB stars.

**Accepted by A&A Suppl. Ser. 118, 1** *Preprints from* thb@mpe-garching.mpg.de
*or on the web at* http://www.rosat.mpe-garching.mpg.de/∼thb/public.html

## The interaction of NGC 6888 and HD 192163 with the surrounding interstellar medium

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We investigate the neutral gas distribution and kinematics in the surroundings of the WR star HD 192163 and the ring nebula NGC 6888, based on HI 21 cm line observations carried out with the Synthesis Telescope of the DRAO.

A detailed analysis of the HI distribution at low positive velocities allowed us to identify two different structures very probably related to the star and the ring nebula. From inside to outside they are: 1) an elliptical shell, 11.8 x 6.3 pc in size, that embraces the ring nebula (labelled **inner shell**); and 2) a distorted HI ring, 28 pc in diameter,

also detected in IR emission (**outer shell**). The borders of the **inner shell** strikingly follows the brightest regions of NGC 6888, showing the sites where the interaction between the nebula and the surrounding gas occurs. A third structure, the **external feature**, is a broken arc detected at sligthly higher velocities than the former shells.

We propose a scenario in which the strong stellar wind of HD 192163, expanding in an inhomogeneous interstellar medium, blew the outer shell during the main sequence phase of the star. Later, the material ejected by the star during the LBV (or RSG) and WR phases created NGC 6888. This material encountered the innermost wall of the outer shell originating the inner shell. The association of the external feature with the star and the nebula is not clear.

**Accepted by Astron.J.** *Preprints from* ccappa@fcaglp.fcaglp.unlp.edu.ar

## The variable mass loss of the peculiar supergiant P Cygni

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The study of iron lines from 49 high–resolution *IUE* spectra observed in the period of 1985–1991 allowed us to find a repetition time between two successive shells of the order of six months. We found that absorption lines of Fe III often have two components while Fe II lines can have three. P Cygni is the only LBV which does not show photometric variability on the scale of 1–$2^{\rm m}$ and the only one whose shell phenomena have been followed for some considerable time. The recent disappearence of shell components observed in Si, O and N lines during the last decades is possibly a new unique phenomenon.

**Accepted by MNRAS** *Preprints from* `garik@ster1.vub.ac.be`

## B 517 – Another very late WNL star in M33

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We present intermediate dispersion optical spectroscopy of the M33 star B 517 (Humphreys & Sandage 1980) obtained at the 3.5m Calar Alto and 4.2m William Herschel Telescopes. Our data reveal a spectral type of WN11h, closely resembling the Galactic LBV candidate He 3–519 (Smith et al. 1994). We find that B 517 is the WNL star observed by Esteban et al. (1994), named MC 70 therein, and present a spectral analysis using the Hillier (1990) iterative scheme. We find that its stellar parameters ($T_*$=27kK, log $L/L_\odot$=5.74, log $\dot{\rm M}/(M_\odot\,{\rm yr}^{-1})$=−4.3, $v_\infty$=275 km s$^{-1}$) are similar to LMC WN11 stars (Crowther & Smith 1996), with a higher helium content (H/He∼0.8 by number), suggesting a post-LBV evolutionary status.

**Research Note accepted by Astronomy & Astrophysics**
*Preprints available via anonymous ftp - please contact* `pac@star.ucl.ac.uk`

## Submitted Papers

# The orbit of the supergiant component of Vela X-1 derived from IUE radial velocities

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Forty-seven short-wavelength, high-resolution IUE spectra have been used to derive the orbital elements of HD 77581, the supergiant companion to the neutron star in the X-ray source Vela X-1; the velocity amplitude is at the lower end of the range found by previous workers using primarily optical spectra but the other elements are in fair agreement with those derived from pulse-timing studies of the X-ray source. The new results indicate that the mass of the neutron star is close to 1.4 $M_{\odot}$ and is not significantly larger than those measured for other members of this class of object.

**Submitted to Monthly Notices of the RAS** *Preprints from* `ds@astro1.bnsc.rl.ac.uk`

## Thesis

# Starbursts in barred spiral galaxies

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The purpose of this work was to determine quantitatively the interplay between the properties of starbursts, the interstellar medium and the barred morphology of galaxies. A global study of starburst galaxies is necessary not only to understand different processes of star formation but also to predict chemical and dynamical evolution of galaxies and, in a larger extent, to put constraints on stellar evolution models.

This thesis is a global study of starbursts in barred spiral galaxies, based on multi-wavelength observations of a large and homogeneous sample of galaxies. A sample of 144 galaxies was constructed using three selection criteria (bar + Markarian + IRAS). Most of these galaxies are effectively the site of starburst activity.

The precise determination of starburst properties is the main result of this work. The age and star formation rate of 199 nuclear and extranuclear starbursts were estimated after removing about thirty galaxies with active nucleus (Seyfert 1 and 2) from my sample using spectrophotometric observations. The starbursts age was computed using two recent stellar population synthesis models (Cerviño & Mas-Hesse 1994, Leitherer & Heckman 1995). A large proportion of very young starbursts with age between 3 and 6 Myr are found in our sample of galaxies. The discovery of about 450 Wolf-Rayet stars in a giant H II region of Mrk 712 corroborate the precocity of the starburst in this galaxy, since I found an age lower than 4 Myr. The initial mass function in the giant H II region of Mrk 712 is nearly flat, suggesting the formation of a large number of massive stars in this galaxy.

The study of the neutral (atomic and molecular) gas shows mainly the quality and homogeneity of the sample. The far-infrared luminosity is strongly correlated with the H$\alpha$ luminosity and the molecular

hydrogen mass. These linear correlations show that massive stars, which produce the H$\alpha$ emission, are the main heating sources of dust and hence the main contributors of the far-infrared luminosity.

A relation between the distribution of molecular clouds and the starburst age has been established. Molecular clouds are highly concentrated in the center of young starburst galaxies, while their distribution is more extended in older starburst galaxies. The dense molecular gas content in three Wolf-Rayet galaxies is not high compared to other starburst galaxies. A large quantity of dense molecular clouds must be present to generate starbursts, but they are dissipated or ionised very quickly by massive stars recently born.

A majority of starburst galaxies have a strong bar and about half of them show several types of morphological evidence for gravitational interactions. The instabilities created by these perturbations (bar and/or interactions) should be the dynamical origin of the starbursts by fuelling the molecular gas toward the center of galaxies.

**Ph.D. Thesis (in french) completed at the University of Toulouse, April 16 1996, under the direction of Dr. Emmanuel Davoust.** *For copies, contact* `contini@obs-mip.fr`

# Meetings

## First Announcement for a Proposed Meeting on B[e] Stars

Since the spectra of B[e] stars are characterized by a large extinction of several magnitudes in the UV and the visual, they have been observed rather infrequently by spectroscopists in the past. As a result, our knowledge of the group is rather incomplete. Although about one hundred galactic objects have been classified as such, only some fifteen have been studied in detail. Besides this, the evolutionary status of the objects is rather controversial; are they pre-main sequence stars, or, on the contrary, are they stars on their way to becoming planetary nebulae? B[e] stars are charcterized by a large infrared excess due to their dust envelope and will thus be easily detectable through new infrared surveys like DENIS, which shall reach K=14.5. Besides the DENIS survey in the south we shall also have the 2MASS data from the northern hemisphere, and more data coming from the micron, the millimeter and the centimeter wavelength regions. Before these new data arrive, it seems that time is ripe to make a survey of our knowledge of these objects.

We propose thus to organize a Workshop on B[e] stars at Paris, toward the end of spring 1997. Although the emphasis of the meeting shall be placed on the spectroscopic side, other aspects will be covered well. Besides the controversial evolutionary status already mentioned, another important point is the relation of B[e] stars with other stellar groups, like Be, Herbig-Haro, luminous blue variables and the B[e] stars observed in the Magellanic Clouds.

We would like to know both your interest in this workshop and if you expect to attend. For organizational reasons, we would prefer an answer (with your name, institute, postal address, e-mail and telex/fax) before August 1st, 1996.

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# ISO's View on Stellar Evolution

July 1-4, 1997, Noordwijkerhout, the Netherlands

## Goal of the workshop

The *Infrared Space Observatory* was successfully launched on November 17, 1995, and has now entered its routine phase operations. First results of the four focal plane instruments will be presented at a workshop in ESTeC at the end of May 1996. It is expected that by the summer of next year (1997) many observers will have had the opportunity to study *ISO* data in detail and therefore that time would be appropriate to organize a scientific workshop in the context of *ISO*.

This workshop will focuss on stars and circumstellar matter. It has become clear in the past decade that circumstellar matter plays a crucial role in stellar evolution, both when stars are in their infancy and when they approach the end of their life. It is expected that *ISO* will provide a major breakthrough in our understanding of the evolution of stars and their circumstellar environment. A large fraction of *ISO*'s observing time is aimed at the study of circumstellar matter throughout the life of stars.

The workshop will have three major topics: (1) the birth of stars and planetary systems, (2) the winds of hot stars as viewed from the IR, (3) late stages of stellar evolution. While these three areas cover a wide scope, we believe that bringing researchers from these different disciplines together in the context of *ISO* will give important new impulses to these fields, since the physical and chemical conditions that prevail in circumstellar matter around objects in very different evolutionary stages are often similar, i.e., diagnostic tools are alike.

### Organization

Scientific Organizing Committee:
Rens Waters (chairman), Christoffel Waelkens (co-chairman, België), Teije de Jong, Harm Habing, Karel van der Hucht, Thijs de Graauw, Mike Barlow (UK), Steve Beckwith (BRD), Rolf Kudritzki (BRD), Antonella Natta (Italia), Thomas Henning (BRD), Eric Becklin (USA), Tsuji (Japan), Timo Prusti (ESA), and Daniel Rouan (France).
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