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

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ed. Philippe Eenens

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Accepted Papers

The *IUE* MEGA Campaign: Wind Variability and Rotation in Early-Type Stars

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Wind variability in OB stars may be ubiquitous, and a connection between projected stellar rotation velocity and wind activity is well established. However, the origin of this connection is unknown. To probe the nature of the rotation connection, several of the attendees at the workshop on *Instability and Variability of Hot-Star Winds* (Moffat et al. 1994) drafted an *IUE* observing proposal. The goal of this program was to follow 3 stars for several rotations to determine whether the rotation connection is correlative or causal. The stars selected for monitoring all have rotation periods ≤ 5 days. They were: HD 50896 (WN5), HD 64760 (B0.5 Ib), and HD 66811 (ζ Pup, O4 If(n)). During 16 days of nearly continuous observations in 1995 January (dubbed the 'MEGA' campaign), 444 high dispersion *IUE* spectra of these stars were obtained. This *Letter* presents an overview of the results of the MEGA campaign and provides an introduction to the three following *Letters* which discuss the results for each star.

Accepted by ApJ Letters. *For preprints, contact* massa@godot.arclch.com. Preprints available on the Web at http://www.ari.net/MEGA/ or by anonymous ftp from godot.arclch.com in the /pub/mega directory.

The *IUE* MEGA Campaign: Wind Structure and Variability of HD 50896 (WN5)

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We present preliminary results from an extensive study of UV line and continuum variability in the WN5 star HD 50896 = EZ CMa, monitored over 16 consecutive days in January 1995, as part of the IUE 'MEGA' campaign. Although variations are seen in all of the major emission lines, the clearest occur in the unsaturated, subordinate NIV 1718 Å line, and in the large number of FeV/VI lines in the $\lambda\lambda$ 1260–1450 Å region. These and the continuum variations are clearly locked into the 3.766 day period, which has been known for this star since 1980.

The observed variations suggest a global wind structure pattern that remains quite stable in the frame of the star, over the duration of the observations. This pattern is marginally compatible with that expected for the ionization cavity around an accreting neutron star companion in a 3.766 day WR + NS binary. However, it can best be explained by some kind of corotating interaction regions emanating from hot (magnetically?) active regions near the surface of the stellar core. Such a model, although somewhat *ad hoc*, better accounts for the strong epoch-dependent variations seen in EZ CMa, as well as the fine structures seen in the global pattern.

Accepted by ApJL *For preprints, contact* sergey@ASTRO.UMontreal.CA
Available by anonymous ftp: ftp.astro.umontreal.ca cd incoming/sergey/ezcma/*.*

THE *IUE* MEGA Campaign. Modulated structure in the Wind of HD 64760 (B0.5 Ib)

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We highlight systematic variability in the stellar wind of the early B-type supergiant, HD 64760, whose UV line profiles were monitored for almost 16 days in 1995 January as part of the *IUE* 'MEGA Campaign'. The extensive coverage reveals a pattern of rapidly evolving discrete optical depth changes which typically migrate from $\sim$ –200 km s^{-1} to $\sim$ –1500 km s^{-1} in less than 12 hours. These features co-exist with more slowly evolving structures lasting several days. Time-series analysis of the Si IV, Si III, and N V profile variations presents a clear 1.2 day periodicity, which is a quarter of the estimated maximum rotation period of HD 64760. The line profile changes are consistent with an interpretation in terms of a set of co-rotating wind features which occult the stellar disk at least 3 times during the observing run. These data are combined with UV observations collected in 1993 March to argue persuasively in favour of rotationally modulated wind variations in HD 64760.

The basic result of very regular, large-scale optical depth variations points to a 'clock' whose origin is on the stellar surface, rather than a mechanism that is entirely intrinsic to the stellar wind.

Accepted by Ap.J.Letters *For preprints, contact* rkp@starlink.ucl.ac.uk

The *IUE* MEGA Campaign. The Rotationally Modulated Wind of Zeta Puppis

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We discuss 16 days of intensive *IUE* observations of the Si IV doublet (λ1400 Å) in the spectrum of the O4 I(n)f star ζ Pup. The data show continuous variability throughout the greater part of the blue-shifted absorption. Time-series analysis of these data reveals significant power at periods of 19.2 h and 5.2 d, which we identify with the mean recurrence time of 'discrete absorption components' (DACs) and the photospheric rotation period, respectively. These results indicate that the wind has a global longitudinal asymmetry (approaching a factor 2 in optical depth), possibly associated with large-scale magnetic structures, but suggest that the DACs are not directly associated with specific stellar longitudes in this star. There is no significant power in the lines at the 8.5-h period identified in photospheric absorption-line variability, nor at the 16.7-h period reported in X-ray observations.

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A pulsating star inside Eta Carinae. I. Light variations, 1992-1994.

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We present and analyze two seasons of intense photometric monitoring in the Strömgren uvbyβ system of Eta Carinae (October 1992 - August 1994). The luminous blue variable (LBV) in the core did not show much S Dor activity, i.e. it was in a relatively quiescent stage. This situation was very favourable for studying its optical micro variations. It appears that the central LBV pulsates (presumably in a non-radial mode) like other massive evolved stars, the α Cyg variables. The quasi- period is 58d56. The linear ephemeris is: JDmax = 2448875.0 + 58.56 E. Support was found for the existence of the presumed periodicity of 52d4 of the so-called "dimples", shallow dips in the light curve which last for a few days. The cause may be the eclipse of a small companion, or of a hot spot in an accretion disk. The Ha index became bluer by 0m07 during the last 1 1/2 y and shows an oscillation in anti-phase with the 58d56 pulsation, suggesting that the HII region(s) responsible for the hydrogen line emission has a relatively high luminosity. This is another reason to suppose that a second luminous source, perhaps a luminous disk (with a hot spot), may be present in the Eta Car system.

Accepted by A&A. *For preprints, contact* genderen@strw.LeidenUniv.nl

About the absence of a proper zero age main sequence for massive stars

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The formation of stars up to 120 $M_\odot$ is computed in the framework of the accretion scenario. For realistic accretion rates derived from the observed line width in various molecular dark clouds, the accretion interlude lasts some 2-2.5 Myr, and accounts for an appreciable nuclear evolution during the optically thick MS life. Several new results are found concerning massive stars at the top of the MS: 1) A newly formed massive star with M $\geq$ 40 $M_\odot$ at the time it emerges from its parental cloud has already burned a substantial fraction of its central hydrogen content. 2) As a consequence, the formal MS lifetime is substantially reduced. 3) A proper ZAMS does not exist, since at the time it becomes visible, the star has already evolved towards lower T_{eff}. 4) As a result of previous evolution, the size of the convective core for a given central H content is reduced by about 5-10 %. 5) We find that for realistic accretion rates applicable to ordinary star forming regions in the Galaxy and Magellanic Clouds, a truncation of the IMF is naturally established around 85-150 $M_\odot$ where the accretion time becomes comparable to the hydrogen burning time. 6) Since massive stars spend a fraction of their H-burning phase in the parental cocoon, their true number is larger than estimated and the slope of the IMF is flatter.

Accepted by A&A *For preprints, contact* berna@scsun.unige.ch
Preprints are available from the anonymous ftp-server obsftp.unige.ch directory /pub/Preprints/ - file birth.ps or via WWW at http://obswww.unige.ch/Preprints

O Stars in Transition.
I. Optical Spectroscopy of Ofpe/WN9 And Related Stars

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Ofpe/WN9 stars have become one of the keys for understanding the physics of very strong stellar winds and their consequences for the evolution of massive stars. This paper is the first part of a comprehensive effort to understand the role of Ofpe/WN9 stars in the uppermost part of the Herztprung-Russell Diagram. First, we report the results of a complete literature search on aspects most relevant to the goal of our study. This provides a database which will be used for the interpretation of our observational and theoretical results. Second, we present a complete data-set of new ground-based data. We present here high S/N, high spectral resolution echelle observations of 7 Ofpe/WN9 stars and 6 closely related stars, with the objective to establish similarities and differences between individual objects and stellar groups, in an attempt to shed light on the true nature of Ofpe/WN9 stars.

Our findings show that the Ofpe/WN9 stars form a homogeneus group, in terms of spectral distribution and wind properties, with characteristics somewhere in between the Of stars on one hand (with the weakest winds) and the B[e] stars on the other. We also find that, at least for the Of-Ofpe/WN9 stars, this progression corresponds to an evolutionary sequence. In fact, in two of the observed Of sta‘ in our sample (HDE313846 and HD152408) the appearance of P Cygni profiles and strengthened emission components in both H and He I lines seem to suggest they are in a transition phase between Of and Ofpe/WN9.

We also find that five of the Ofpe/WN9 star spectra show the presence of nebular emission lines, indicating a surrounding nebulosity. We examine all the cases individually and conclude that only for S119 and BE381 is there a clear case for an expanding shell associated with the star. This would strengthen the connection between Ofpe/WN9 stars and LBVs, which also are often surrounded by circumstellar nebulae generated during one or more "violent outbursts" in their recent evolution history.

Submitted to The Ap J Suppl *For preprints, contact* nota@stsci.edu

Submitted Papers

An explanation for the [Ne III] problem in H II regions

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By means of realistic model atmospheres for O-type stars, we investigate the influence of EUV radiation

on the ionization structure of H II regions. Our model calculations are based on a detailed multilevel NLTE treatment including *radiation-driven wind theory* and a consistent calculation of *NLTE line blocking opacities* for all important ionization stages.

Applying our emergent fluxes to a standard nebular code (kindly provided by G. Ferland) we find, compared to other investigations, an improved match between the observed and calculated ionization structure. In particular, the relatively high ionization fraction of Ne^{++} is well reproduced by our calculations. Thus, our emergent ionizing fluxes provide a solution to the persistent [Ne III] problem in H II regions. In addition, the fractions of O^{++} and S^{++} are changed with the consequence that the relation between the ratio O^{++}/S^{++} and the temperature of the ionizing source is modified.

The spectral distribution of our ionizing fluxes is mainly influenced by two partly compensating processes of (i) metal line blocking and (ii) the effect of a stellar wind. Even very low mass-loss rates affect the subsonic density structure and, consequently, the emergent flux.

Submitted to A&A letter *For preprints, contact* florian@usm.uni-muenchen.de

A Reconnaissance of the 900–1200 Å Spectra of Early O Stars in the Magellanic Clouds

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The first survey of the far-UV (900–1200 Å) spectra of O stars in the Magellanic Clouds, observed with the Hopkins Ultraviolet Telescope during the Astro-2 mission, is presented. Five objects in each Cloud were obtained, including four of type O3 (one of which is the current candidate for the most massive star known) and a pair of O4 If supergiants with remarkably different relative CNO strengths. All of the SMC objects are in its largest H II region, NGC 346, and show strong effects of the systemic metal deficiency. The systematic spectral-type dependence of the numerous stellar-wind features in this relatively little-studied wavelength range, including those of O VI and S VI, is illustrated and described. One of the LMC O3 stars, with $E_{B-V} = 0.25$, displays strong interstellar H_2 features. Finally, the 900–1800 Å spectrum of the peculiar WN eclipsing binary HD 5980 in the SMC, observed during the decline from its unprecedented late-1994 giant outburst, is also shown.

Submitted to APJL *For preprints, contact* walborn@avion.stsci.edu

Hydrodynamical Simulations of Corotating Interaction Regions and Discrete Absorption Components in Rotating O-Star Winds

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We present two-dimensional hydrodynamical simulations of corotating stream structure in the wind from a rotating O star, together with resulting synthetic line profiles showing discrete absorption components (DACs). An azimuthal variation is induced by a local increase or decrease in the radiative driving force, as would arise from a bright or dark "star spot" in the equatorial plane. Since much

of the emergent wind structure seems independent of the exact method of perturbation, we expect similar morphology in winds perturbed by localized magnetic fields or nonradial pulsations, as well as by either rotationally-modulated structure or transient mass ejections.

We find that bright spots with enhanced driving generate high-density, low-speed streams, while dark spots generate low-density, high-speed streams. Corotating interaction regions (CIRs) form where fast material collides with slow material – e.g. at the leading (trailing) edge of a stream from a dark (bright) spot, often steepening into shocks. The unperturbed supersonic wind obliquely impacts the high-density CIR and sends back a nonlinear signal which takes the form of a sharp propagating discontinuity ("kink" or "plateau") in the radial velocity gradient. These features travel inward in the co-moving frame at the radiative-acoustic characteristic speed, and thus slowly outward in the star's frame. We find that these slow kinks, rather than the CIRs themselves, are more likely to result in high-opacity DACs in the absorption troughs of unsaturated P Cygni line profiles. Because the hydrodynamic structure settles to a steady state in a frame corotating with the star, the more tightly-spiraled kinks sweep by an observer on a longer time scale than material moving with the wind itself. This is in general accord with observations showing slow apparent accelerations for DACs.

Submitted to Ap J. *For preprints, contact* cranmer@bartol.udel.edu
Also available on the **www** at: http://www.bartol.udel.edu/~cranmer/hot_pre.html

Meetings

Information about the **Workshop on Colliding Winds in Binary Stars**, La Plata, Argentina, November 21-24 1995, can be obtained at URL: http://www.fcaglp.unlp.edu.ar/winds.html
or from Virpi Niemela (virpi@fcaglp.fcaglp.unlp.edu.ar)
Scientists interested in the workshop are invited to *register* and to *submit abstracts* by October 1st.

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PRELIMINARY PROGRAM (and invited speakers)

Session 1. Mass Flow in Binary Stars
              (J. Sahade, Y. Kondo, A. Gimenez, E. Guinan)
Session 2. Observational Evidence of Colliding Winds
              (D. Gies, A. Moffat, M. Corcoran )
Session 3. Models of Colliding Winds
              (S. Owocki, K. Gayley, I. Stevens)
Session 4. Discussion of Objects of Particular Interest
              (R. Barba, R. Koch, G. Koenigsberger, A. Underhill)
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