THE HOT STAR NEWSLETTER

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Contents of this newsletter

From the Editor

This 50th issue again contains many abstracts of interesting papers, starting with another paper to appear in *Annual Reviews of Astronomy and Astrophysics*.

Daniel Schaerer announces the availability of the proceedings of the JENAM session on the *The Interplay between Massive Stars and the ISM*.

Schuyler Van Dyk announces the availability of the second large Incremental Data Release from the *Two Micron All Sky Survey (2MASS)*, consisting of about 47% of both northern and southern sky, with infrared photometry and astrometry for a large number of hot stars both in the Galaxy and in the Magellanic Clouds.

Mike Corcoran sent us an update on the X-MEGA campaign.

This issue also includes the scientific programs of the forthcoming meetings announced in the previous issue.

News

The Interplay between Massive Stars and the ISM

Proceedings of Session I of the JENAM99 meeting held in Toulouse, France, 7 - 11 September 1999

Proceedings of the two day session on "The Interplay between Massive Stars and the ISM" held during the The Joint European and National Astronomical Meeting (JENAM99) of the European Astronomical Society and the French Astronomical Society in September 1999 will be published in spring 2000 in *New Astronomy Reviews*.

The scientific program includes three main topics:

- Stellar content and physics of massive star-forming regions (giant HII regions, starbursts)
- Chemical enrichment by massive stars
- The dynamical impact of star formation on the ISM from small to large scales

The table of content and preprints are now available on the Web at
`http://webast.ast.obs-mip.fr/people/schaerer/jenam99/proceedings.html`

The Two Micron All Sky Survey Second Incremental Data Release

Schuyler Van Dyk

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The Two Micron All Sky Survey (2MASS) Second Incremental Data Release is now available for public access. This Release includes data from the northern and southern 2MASS facilities, covering 47The Release data products consist of a Point Source Catalog containing positions and photometry for over 162 million objects, an Extended Source Catalog containing positions, photometry and basic shape information for over 585,000 resolved sources, approximately 1.9 million compressed 512x1024 pixel (1"/pixel) images in the three Survey bandpasses, and non-compressed "postage-stamp" images for all of the Extended Source Catalog objects.

The release data products can be accessed on-line from the IPAC/2MASS Web site at
`http://www.ipac.caltech.edu/2mass/`
or directly from the NASA/Infrared Science Archive site at
`http://irsa.ipac.caltech.edu/` .
In the near future, the release Catalogs will be available via ftp download, and on a limited distribution DVD-ROM. Access to the 2MASS Atlas Images is currently possible only via the on-line services.

The 2MASS/IPAC webpage contains general information about this data release, including an on-line Explanatory Supplement (http://www.ipac.caltech.edu/2mass/releases/second/doc/explsup.html), sky coverage maps, images of interesting objects in the release, catalog characteristics, etc. A tool for determining whether a specified position is included in the release area is available on the NASA/Infrared Science Archive webpage. Questions about the release can be directed to the 2MASS Help Desk at 2mass@ipac.caltech.edu.

We encourage you to notify us (at 2mass@ipac.caltech.edu) about any refereed publications or conference proceedings (even in preprint form) which make use of these or earlier 2MASS Release data products. We will gladly provide links to your papers from the 2MASS website. Thank you very much in advance.

The 2MASS Project

The Two Micron All Sky Survey is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology. Funding for the survey has been provided by the National Aeronautics and Space Administration and the National Science Foundation.

An Update on the Activities of the XMEGA group: WR 140, Iota Ori, and upcoming observations.

Mike Corcoran

USRA/GSFC-LHEA, Code 662, GSFC, Greenbelt, MD 20771 USA

The XMEGA group is a loose association of astronomers sharing an interest in high energy (X-ray and gamma-ray) emission from massive stars, and in exploring the connection between high energy emission and phenomena in other wavebands. This group is comprised of over 50 scientists around the world. More information about the XMEGA group can be found at:

http://lheawww.gsfc.nasa.gov/users/corcoran/xmega/xmega.html

The most recent results of the XMEGA group are:

- Our WR140 X-ray observing campaign with the X-ray observatory ASCA is nearing completion. Our group has been awarded observing time by ASCA for twice-yearly snapshots from 1997, to cover the interval apastron to periastron, and includes ground-based coordinated observations by Dominique Ballereau and Nancy Morrison, among others. Preliminary results of this campaign were presented at IAU symposium 193, "WOLF-RAYET PHENOMENA IN MASSIVE STARS AND STARBURST GALAXIES", November, 1998. Andy Pollock is currently taking the lead on summarizing the results of this multi-year, multi-wavelength observing campaign.
- Julian Pittard has submitted a paper to the MNRAS discussing the results of our ASCA observations of the O binary Iota Ori. We expected to see strong changes in the X-ray emission at periastron compared to apastron, but surprisingly this wasn't the case. Sergey Marchenko has published a companion paper discussing possible interaction effects observed near the times of the ASCA observations.
- We are anxiously awaiting the scheduling of our observation of NGC 3603 by Chandra and HD 5980 by XMM-Newton.

More information about the scheduling of these observations will be posted on the XMEGA web page as available. In particular we encourage any and all coordinated observations in other wavebands. If anyone wants more information or would like to be put on the XMEGA mailing list please contact Mike Corcoran (corcoran@barnegat.gsfc.nasa.gov)

Accepted Papers

Winds from Hot Stars

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This review deals with the winds from "normal" hot stars such as O-stars, B- and A-supergiants and Central Stars of Planetary Nebulae with O-type spectra. The advanced diagnostic methods of stellar winds including an assessment of the accuracy of the determinations of global stellar wind parameters (terminal velocities, mass-loss rates, wind momenta and energies) are introduced and scaling relations as a function of stellar parameters are provided. Observational results are interpreted in the framework of the stationary, one-dimensional theory of line driven winds. Systematic effects caused by non-homogeneous structures, time dependence and deviations from spherical symmetry are discussed. The review finishes with a brief description of the rôle of stellar winds as extragalactic distance indicators and as tracers of the chemical composition of galaxies at high redshift.

Accepted by Annual Reviews of Astronomy and Astrophysics

Preprints from `kud@usm.uni-muenchen.de`

or on the web at

`http://www.usm.uni-muenchen.de/people/kud/papers/review_einz.ps`

ASCA spectroscopy of the hard X-ray emission from the colliding wind interaction in γ^2 Velorum

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We discuss an *ASCA* observation of the eccentric WC8 + O7.5 III binary γ^2 Velorum near apastron. The X-ray spectrum is compared to two previous observations obtained when the system was near periastron. All three spectra display a hard emission component that undergoes strong variability over the orbital cycle. The properties of the hard X-ray emission of γ^2 Vel are constrained by taking into account the contribution from contaminating soft X-ray sources in the vicinity of γ^2 Vel. We find that the observed variations are in qualitative agreement with the predictions of colliding wind models. We investigate for the first time the effect of uncertainties in the chemical composition of the X-ray emitting plasma on our understanding of the high energy properties of the wind interaction region. Our results indicate that these uncertainties significantly affect the derived shock temperature and absorption column, but play a smaller role in determining the intrinsic X-ray luminosity of the colliding wind zone. We further find that the intrinsic luminosity from the hard X-ray component in

γ^2 Vel does not follow the 1/D distance relation expected from simple models of adiabatic shocks.

Accepted by Monthly Notices of the Royal Astronomical Society

New aspects of line-profile variability in P Cygni's optical spectrum

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High-resolution photographic spectra as well as high S/N ratio CCD spectral observations of P Cygni are analyzed in terms of line-profile variability (lpv). Four different kinds of lpv are established: systematic variability in the absorption troughs of low and intermediate excitation lines due to propagating Discrete Absorption Components (DACs); "swaying" variability consisting of continuous modulations in velocity and intensity of the absorption cores and emission peaks of lines of intermediate and high excitation; red-emission-wing variability due to travelling "bumps", and long-term (LT) variability in HI and HeI lines of relatively large optical depth.

DAC propagation is a slow variation of P Cygni's stellar wind. The components probably originate from large-scale, high-density (low-excitation) perturbation(s) which develop in a relatively outer part of the wind ($V \geq 0.41V_{\rm inf}$) but appear to be maintained, in some indirect way, by photospheric processes. The geometry of the structures is not yet clear but they could be either spherically symmetric or curved, like kinks.

The "swaying" variability manifests itself by modulations in position and intensity of the absorption cores and emission peaks of almost all lines in the optical. Simultaneous variations in emission and absorption line-strength were also observed. The modulations are at least partially due to variations in the number density which affect all layers of the supersonic wind starting at its base up to layers where the Hα line forms ($0.18 \leq V \leq 0.95V_{\rm inf}$). The phenomenon appears to be stable over many years, though on a variable time-scale. Suggestive evidence for a close relationship between the modulations and changes in the stellar brightness and temperature was found, indicating that the "swaying" variability is more likely coupled to processes in the photosphere. Non-radial pulsations (NRPs) either of g-mode or of s-mode oscillations are a possible cause for this variability.

The LT variability makes up a very slow pattern of variation in both the velocity of the absorption cores and the intensity of the emission peaks of the stronger HI and HeI lines. This variability is found only in the outer part of the wind ($V \leq 0.82V_{\rm inf}$). The nature of the LT variation is not known at present.

The red-emission-wing variability is localized in the high-velocity part of the emission lobes of P Cygni-type profiles, $+90 \leq V \leq +230/250{\rm kms}^{-1}$. This variability is presumably caused by outward propagating "bumps", but its exact nature is still unknown.

No indication for any clear relation between different kinds of lpv was found. Even when the variations operate in one and the same region of the wind (in velocity space) it is not obvious whether and how they interact. Stellar rotation does not seem to play a fundamental role in setting the time-scale of either the DAC-induced variability or the LT variability. The relationship between the "swaying" variability and the rotation is still not clear but it is possible that this variability is rotationally modulated.

The wind variability of P Cygni appears to be qualitatively similar to the wind variability of the early B-type supergiant HD64760 but different from the variability of O-type star winds.

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Preprints from rozhen@mbox.digsys.bg

Quantitative analysis of WC stars: Constraints on neon abundances from *ISO*–SWS spectroscopy

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Neon abundances are derived in four Galactic WC stars – γ^2 Vel (WR 11, WC8+O7.5III), HD 156385 (WR 90, WC7), HD 192103 (WR 135, WC8), and WR 146 (WC5+O8) – using mid-infrared fine structure lines obtained with *ISO*–SWS. Stellar parameters for each star are derived using a non-LTE model atmospheric code (Hillier & Miller 1998) together with ultraviolet (IUE), optical (INT, AAT) and infrared (UKIRT, *ISO*) spectroscopy. In the case of γ^2 Vel, we adopt results from De Marco et al. (2000), who followed an identical approach.

ISO–SWS datasets reveal the [Ne III] 15.5μm line in each of our targets, while [Ne II] 12.8μm, [S IV] 10.5μm and [S III] 18.7μm are observed solely in γ^2 Vel. Using a method updated from Barlow et al. (1988) to account for clumped winds, we derive Ne/He=3–4$\times10^{-3}$ by number, plus S/He=6$\times10^{-5}$ for γ^2 Vel. Neon is highly enriched, such that Ne/S in γ^2 Vel is eight times higher than cosmic values. However, observed Ne/He ratios are a factor of two times lower than predictions of current evolutionary models of massive stars. An imprecise mass-loss and distance were responsible for the much greater discrepancy in neon content identified by Barlow et al.

Our sample of WC5–8 stars span a narrow range in T_* (=55–71kK), with no trend towards higher temperature at earlier spectral type, supporting earlier results for a larger sample by Koesterke & Hamann (1995). Stellar luminosities range from 100,000 to 500,000$L_\odot$, while $10^{-5.1} \leq \dot{M}/(M_\odot \mathrm{yr}^{-1}) \leq 10^{-4.5}$, adopting clumped winds, in which volume filling factors are 10%. In all cases, wind performance numbers are less than 10, significantly lower than recent estimates. Carbon abundances span $0.08 \leq \mathrm{C/He} \leq 0.25$ by number, while oxygen abundances remain poorly constrained.

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Preprints from ldessart@phy.ulaval.ca
or on the web at http://astrosun.phy.ulaval.ca/astro/pub.html

Stagnation and Infall of Dense Clumps in the Stellar Wind of τ Scorpii

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Observations of the B0.2 V star τ Scorpii have revealed unusual stellar wind characteristics: red-shifted absorption in the far-ultraviolet O VI resonance doublet up to $\sim +250$ km s^{-1}, and extremely hard X-ray emission implying gas at temperatures in excess of ĕ7 K. We describe a phenomenological model to explain these properties. We assume the wind of τ Sco consists of two components: ambient gas in which denser clumps are embedded. The clumps are optically thick in the UV resonance lines primarily responsible for accelerating the ambient wind. The reduced acceleration causes the clumps to slow and even infall, all the while being confined by the ram pressure of the outflowing ambient wind. We calculate detailed trajectories of the clumps in the ambient stellar wind, accounting for a line radiation driving force and the momentum deposited by the ambient wind in the form of drag. We show these clumps will fall back towards the star with velocities of several hundred km s^{-1} for a broad range of initial conditions. The velocities of the clumps relative to the ambient stellar wind can approach 2000 km s^{-1}, producing X-ray emitting plasmas with temperatures in excess of $(1-6)\times$ ĕ7 K in bow shocks at their leading edge. The infalling material explains the peculiar red-shifted absorption wings seen in the O VI doublet. Of order 10^3 clumps with individual masses $m_c \sim 10^{19} - 10^{20}$ g are needed to explain the observed X-ray luminosity and also to explain the strength of the O VI absorption lines. These values correspond to a mass loss rate in clumps of $\dot{M}_c \sim$ ĕ-9 to ĕ-8 M$_\odot$ yr^{-1}, a small fraction of the total mass loss rate ($\dot{M} \sim 3\times$ ĕ-8 M$_\odot$ yr^{-1}). We discuss the position of τ Sco in the HR diagram, concluding that τ Sco is in a crucial position on the main sequence. Hotter stars near the spectral type of τ Sco have too powerful winds for clumps to fall back to the stars, and cooler stars have too low mass loss rates to produce observable effects. The model developed here can be generally applied to line-driven outflows with clumps or density irregularities.

Accepted by The Astrophysical Journal

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or on the web at http://fuse.pha.jhu.edu/∼howk/Papers/papers.html

Continuum optical circular polarisation in the young O star Θ^1 Orionis C?

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Recently, Donati & Wade (1999) have claimed rather spectacular, large, variable circular polarisation in the optical continuum of Θ^1 Orionis C, obtained with the échelle spectropolarimeter MuSiCoS. However, based on experience with the William-Wehlau spectropolarimeter, a similar unit using two

fiber feeds, we suggest that this is the spurious result of instrumental effects. We propose a remedy to eliminate the effect.

Accepted by A&A
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Spectroscopy of HD 4004. Search for Fast Spectral Variability.

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We present results of a detailed analysis of spectral variability observed in the optical spectrum of HD 4004 (WR1). On the basis of data obtained during monitoring of this object on 3 consecutive nights in Dec 1993, and two additional nights in Dec 1994 we show that the variability in He Romanii λ 5411, C Romaniv λ 5808and He Romani λ 5876 may reach as much as 50% in equivalent width. This variability shows a systematic, gradual character, which justifies a search for periodicity. We show that the observed spectral-line-profile changes may mimic radial velocity variations but that any real radial velocity variations in the observed lines of HD 4004 are small. Our search for periodicity in the data was unsuccessful: the data do not show periodicities within the time covered by the observations ($\sim$ 2 days). Our data suggest, however, the existence of a longer-term variability pattern. We show that the observed pattern of the Temporal Variance Spectrum in different lines can be *qualitatively* understood interms of stratification.

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Preprints from `aniedzi@astri.uni.torun.pl`
or on the web at `http://www.astri.uni.torun.pl/ aniedzi/`

A Search for Rotational Modulation of X-ray Centers on the Classical Be Star γ Cassiopeiae

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In this paper we discuss X-ray observations of γ Cas obtained in 1998 November with the Rossi X-Ray Explorer (RXTE). The data were obtained nearly continuously over 54 hours, which is about twice the expected rotational period. An earlier RXTE light curve obtained in 1996 March over a 27 hour period showed X-ray flux arising from short-duration shots (flares) superimposed on an undulating "basal" component which was anticorrelated with fluctuations of the UV continuum over a time scale of $\sim$10 hours. The object of the present study was to (a) examine the long-term variations of the X-ray characteristics through comparisons with this earlier data and (b) to determine whether variations of the basal flux repeat during a second rotation period. A comparison of the results with the 1996 data set shows a number of similarities and differences in the X-ray behavior: (i) the mean X-ray level in 1998 was only 60% of the 1996 level, (ii) the basal fluxes in 1998 vary over shorter timescales (less than 2 hours) than in 1996, (iii) the shots were found to show a slightly softer (cooler) mean color than the

basal component in 1998, although they were slightly hotter in 1996, (iv) fluctuations in the colors of the shot and basal fluxes generally track one another in both data sets, (v) cyclical patterns of X-ray flux decreases with a period of about 7.5 hours occurred in both data sets, and (vi) the frequency of shots with a given integrated energy was found to decrease exponentially with energy; however, the rate of decrease in 1996 was slower than in 1998. There was only marginal evidence for a repetition during the second half of the time sequence of long term basal flux variations seen during the first half of the observations. We suspect, however, that the large intrinsic variability of the X-ray source would have masked a true replication.

We also present archival IUE data which shows the presence of UV continuum variations in 1982 with similar characteristics to those seen in 1996. This suggests that the regions responsible for the UV variability are very long lived. The data also provide the basis for a refined but still tentative rotational period of 1.12277 days.

Assuming a flare paradigm and a simple electron beam model, we examine the atmospheric heating expected for the shot events. We conclude that it is possible to explain how the measured shot temperature can be smaller than the temperature deduced for the basal X-ray emission. We also discover that if the beam model is correct, then the electrons within the beam have relatively high energies (> 200 keV) and are nearly mono-energetic.

In three appendices we discuss arguments, first, against the idea that the X-ray emission from γ Cas arises from mass accretion onto a hypothetical white dwarf companion or as flares from a cool companion and, second, *for* its origin from near the surface of γ Cas.

Fundamental parameters of Galactic luminous OB stars V. The effect of microturbulence

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We study the effect of microturbulence in the line formation calculations of H and He lines, in the parameter range typical for O and early B stars. We are specially interested in its effect on the determination of stellar parameters: $T_{\rm eff}$, $\log g$ and specially on the He abundance.

We first analyze the behaviour of H and He model lines between 4 000 and 5 000 Å with microturbulence and find that for O stars only He Romani lines and He Romanii λ 4686 are sensibly affected by microturbulence, and that models with lower gravities, the ones suitable for supergiants, are more sensitive to it.

Using a test procedure we show that the expected changes in $T_{\rm eff}$, $\log g$ and Helium abundance due to the inclusion of microturbulence in the analysis, are small. We analyze five stars (two late, one intermediate and two early O stars) using microturbulence velocities of 0 and 15 kms^{-1} and confirm the result of the previous test. The parameters obtained for 15 kms^{-1} differ from the ones at 0 kms^{-1} within the limits of the standard error box of our analysis. Only later types reduce their He abundance, by 0.02 in ϵ. Comparing with values in the literature we find that the range of our changes agree with previous results. In some cases other effects can add to microturbulence, and further reduce the He abundance up to 0.04. The quality of the line fits only improves for He Romani λ 4471, but not to the extent of completely solving the so–called dilution effect.

Therefore our conclusion is that microturbulence is affecting the derivation of stellar parameters, but its effect is comparable to the adopted uncertainties. Thus it can reduce moderate He overabundances and solve line fit quality differences, but it cannot explain by itself large He overabundances in O stars.

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Preprints from `ccid@ll.iac.es`

X-ray Emission from Colliding Wind Shocks in the Wolf-Rayet Binary WR 140

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We analyze four ASCA X-ray observations of the Wolf-Rayet binary system WR 140 obtained between 1993 and 1997 by making use of hydrodynamic colliding wind (CW) shock models. The analysis shows that the CW shock models are able to accurately reproduce the X-ray spectra at different orbital phases using mass-loss and orbital parameters that are within the ranges allowed by the uncertainties. However, some adjustment in the currently accepted values of the semi-major axis and time of periastron passage may eventually be required. Models that allow for different electron and ion temperatures provide better fits to the data. Extra absorption is inferred from CW shock models above that expected from the winds and interstellar medium, the origin of which is not yet known. We also report the serendipitous discovery of hot plasma at temperatures in excess of $\sim$2 keV and X-ray emission lines in spectra extracted from the diffuse Cygnus superbubble background in the vicinity of WR 140.

Accepted by Astrophysical Journal
Preprints by anonymous ftp to `super.colorado.edu -- cd pub/Preprints -- get wr140-ApJ.gz`
`Then one needs to gunzip and untar the file: gunzip wr140-ApJ.gz -- tar xvf wr140-ApJ`

Submitted Papers

Hubble Space Telescope Observations of the LBV/WR Eclipsing Binary System HD 5980.

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We report the results of HST/STIS observations of the intriguing LBV/WR binary system HD 5980 in

the Small Magellanic Cloud. Although its spectral characteristics (WN6) are currently very similar to those observed in 1995 in the FUV, some of the line fluxes continue with the increasing trend observed since the 1980's. The erupting star still dominates the emission-line spectrum, and a radial velocity curve from UV lines is derived, supporting previous estimates of its mass (50 $M_{\odot}$). A rough estimate of $2 \times 10^{-4} M_{\odot} \mathrm{yr}^{-1}$ for the current mass-loss rate of this star. The only spectral lines attributable to the close companion, are the very extended P Cygni absorption components of the strong UV lines, present only during the eclipse of the eruptor, implying that the wind-wind collision shock cone winds tightly around this companion. A third stellar component contributing to the spectrum is detected through the presence of stationary photospheric absorption lines in the UV spectrum. This object contributes ∼30% to the UV continuum luminosity.

A new set of ISM absorption components at -680 km s^{-1} has appeared due to the shock interface between the slow wind (∼400 km s^{-1} which emerged during the 1994 eruption and the subsequently emerging fast wind (∼2000 km s^{-1}) phases.

Submitted to The Astrophysical Journal
Preprints from `gloria@astroscu.unam.mx`

In Proceedings

Observational Constraints to the Evolution of Massive Stars

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We consider some aspects of the evolution of massive stars which can only be elucidated by means of "indirect" observations, *i.e.* measurements of the effects of massive stars on their environments. We discuss in detail the early evolution of massive stars formed in high metallicity regions as inferred from studies of HII regions in external galaxies.

Invited Paper presented at the Roma-Trieste Workshop 1999 "The Chemical Evolution of the Milky Way: Stars versus Clusters", Vulcano Island (ME, Italy), 20-24 September, 1999, eds. F. Giovannelli & F. Matteucci, Kluwer-Holland (in press)

Preprints from `panagia@stsci.edu`
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Hα and Radio Study of the Stellar Winds from Early Type Stars

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We have studied the wind properties of about 40 O and B supergiants in the northern emisphere, through the analysis of their Hα lines, as observed with the echelle spectrograph of the Catania Astrophysical Observatory. The profiles were fitted with our model calculations so as to derive the

mass loss rate and the wind velocity field for each star in the sample. On this basis, we have considered the possible correlations between the wind properties and the physical parameters of the stars, with the following results:
1) In O and B supergiants, the mass loss rate depends only on the bolometric luminosity. Considering also stars in different evolutive stages (i.e. giants or main sequence stars), we find that there must be an additional parameter that influences the mass loss rate, as indicated by the existence of parallel sequences in the $\log \dot{M} - \log L$ diagram for different luminosity class stars.
2) The wind velocity structure is strongly correlated with the radiation field of the star. In particular, the wind initial velocity increases with the effective temperature and with the escape velocity.
3) The kinetic energy needed to accelerate the wind to its terminal velocity corresponds to a fraction of the gravitational potential which is the same regardless of the spectral type.
4) Single and/or multiple scattering of UV radiation by (mostly) resonance lines are able to provide the wind with the impulse necessary to its acceleration.

A subsample of the stars from our Hα survey was also observed at radio wavelengths using the VLA. Besides providing a consistency check, the two independent determinations of the mass loss can provide valuable information about the detailed structure and the symmetry of the expanding envelope because radio and Hα emission originate from different parts of the wind. Our radio effort proved to be very successful, in that, out of 19 O and B type supergiants selected and observed, we detected 14 sources, 9 of them for the first time. The main results of our combined radio-Hα study can be summarized as follows:
1) The radio emission turned out to be of thermal origin for all objects detected at least at two frequencies but one (8 out of 9 stars).
2) We find good agreement between radio derived mass loss rates and the Hα ones, with the Hα method providing more accurate determinations of the mass loss rate.
3) Only for one object The radio emission spectral index is found to be equal to the canonical value of 0.6. All other objects have higher spectral indexes, with a mean value is 0.82 and a rms dispersion of ± 0.13. Deceleration at large distances and/or the presence of a temperature gradient may explain this behaviour.
4) The relationship $\dot{M} - L$ for O and B supergiants obtained from the combined Hα and radio results turns out to be appreciably flatter than commonly reported, i.e. $\log \dot{M} = (1.1 \pm 0.1) \log L$.

To appear in *Thermal and Ionization Aspects of Flows from Hot Stars: Observations and Theory;* **ASP Conf. Series, eds. H.J.G.L.M. Lamers & A. Sapar**

EUV/X-ray Emission and the Thermal and Ionization Structure of B Star Winds

David H. Cohen,[1,2] Joseph P. Cassinelli,[3] Joseph J. MacFarlane,[2] and Stanley P. Owocki[1]

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We discuss the EUV and X-ray properties of B stars, focusing on ϵ CMa (B2 II) which is the *only* star with both emission lines and a photospheric continuum detected with *EUVE*. We explore the modest effects of the photospheric EUV continua on the wind, as well as the much stronger effects of the short-wavelength EUV and soft X-ray emission lines. Attenuation of the EUV and soft X-ray emission

by the wind plays an important role, and leads to the reprocessing of X-rays via He^+ ionization and the Bowen mechanism in the wind. Finally, we explore some of the new diagnostics that will shortly become available with the next generation of high spectral resolution X-ray telescopes. All of this analysis is presented in the context of a two component stellar wind–a dense component (clumps) that contains most of the mass but fills a negligible fraction of the volume, and a rarefied component that fills most of the volume but accounts for only a small fraction of the mass.

To appear in Thermal and Ionzation Aspects of Flows from Hot Stars: Observations and Theory, A.S.P. Conf. Ser. 204
Preprints from `cohen@bartol.udel.edu`
or by anonymous ftp to `ftp.bartol.udel.edu/cohen/tartu/Bstar-ioniz.tar.gz`
or on the web at `www.bartol.udel.edu/ cohen/papers/tartu.ps`

Theses

Dynamic and Static Conditions in the Atmospheres of Luminous Blue Variables – A Study of High-Resolution Spectra in the Optical Wavelength Range

Thomas Gäng

NASA/GSFC, Code 682.4, Greenbelt, MD 20771, USA

We have observed the galactic BA-type hypergiant HD 160529 from 1992 to 1995 on 55 – 129 consecutive nights per year to study the spectral variability of Luminous Blue Variables (LBVs). The covered spectral wavelength range was $3450\,\text{Å} \lesssim \lambda \lesssim 8630\,\text{Å}$ with a spectral resolution of $R = \lambda/\Delta\lambda \approx 20\,000$ (i.e. $\approx 15\,\text{km}\,\text{s}^{-1}$).

Time-series analyses of the spectra result in dominant periods of 92.5 ± 1 days for photospheric line profile variations (LPVs) and 114 – 127 days for wind LPVs, which are in a range similar to observed photometric variation time scales. Temporal variance spectra and LPVs indicate radial (RP) and low-order ($|m| \lesssim 2$) non-radial (NRP) pulsations, e.g. retrograde moving variation features of the photospheric He I λ5876 line are well reproduced by NRPs with $l = +m = 1$.

TLUSTY 194 models of the temperature sensitive Ti II λ4468 line indicate a variable temperature structure of the photosphere in the range of $T_{\text{eff}} \approx 10\,000 - 11\,500\,\text{K}$. Temperature variations of this order are expected in RPs and NRPs with $l \lesssim 2$ (Guzik, private communication) and can change the continuum radiation sufficiently to explain the observed variations of the wind lines. Dynamical wind models using the SEIDYNAMIC code confirm these results and demonstrate that even substantial density variations in the stellar outflow cannot be the main cause of the wind variability.

In a second project we have obtained very high resolution spectra ($R \approx 50\,000 - 100\,000$) of 20 LBVs to study their wind structure. *All* objects show inhomogeneities in their line profiles indicating that clumping might be a common feature in LBV-winds. The inhomogeneities get more pronounced and more frequent in spectral lines that are formed further out in the atmosphere. The resulting picture is that of an initially "smooth" wind that gets disturbed and forms clumps or shells as it travels away from the star into the interstellar medium. Possible mechanisms causing this situation are discussed but firm results must be refered to future detailed analyses of these spectra.

PhD Thesis, defended at the University of Heidelberg, Germany on February 16, 2000 (Referees:

Prof. Dr. Bernhard Wolf and Prof. Dr. Rainer Wehrse)
Preprints from gaeng@cheyenne.nascom.nasa.gov
or on the web at http://chippewa.nascom.nasa.gov/gaeng

Meetings

July 10-14	**Interacting winds from massive stars**
Québec	http://www.astro.umontreal.ca/iwinds/
	e-mail: Moffat@astro.uMontreal.ca
August 10	**Massive star birth** (IAU General Assembly)
England	http://www.iau-ga2000.org/
	http://www.iau.org/ib85/sciprog.html#jd3
	e-mail: pconti@jila.colorado.edu
August 21-23	**P Cygni 2000: 400 years of progress**
Ireland	http://www.arm.ac.uk/∼mdg
	e-mail: mdg@star.arm.ac.uk
August 21-25	**The influence of binaries on stellar population studies**
Belgium	http://homepages.vub.ac.be/∼wvanrens/bin_conference/
	e-mail: dvbevere@vub.ac.be
August 24-26	**η Car & other mysterious stars**
Sweden	http://ferrum.fysik.lu.se/hven2000
	e-mail: Hven2000@fysik.lu.se Fri

Interacting Winds from Massive Stars

An International Workshop to be held at
Les Îles-de-la-Madeleine, Québec, Canada
10-14 July 2000

Deadline: The registration deadline is May 1st

Scientific Program

A. Setting the Stage

Anthony Moffat, *Observational Highlights of Interacting Winds*
Stanley Owocki, *Theoretical Highlights of Interacting Winds*

B. Stellar Winds Interacting with Their Circumstellar and Interstellar Environments

Diagnostics

1. Interaction of Stellar Winds and the Interstellar Medium

Magdalen Normandeau*[1], *Stellar Winds of O Stars and the ISM*
Cristina Cappa*, *Interstellar Bubbles: the Neutral and Molecular Components and the Energetics*

[1]* Possible participants

Marcelo Arnal*, *The Influence of O and WR Stars on the ISM*
Eric Keto, *Dynamics of the HII/H2 Interface: Observations*
Marielle Stegeman*, *Interacting Winds and the ISM*
Nicole St-Louis, *HI Bubbles Around WR Stars*
Anthony Marston, *Neutral Gas in the Environments of Evolved Massive Stars*
Olga Sholukhova*, *The Interacting Winds of New LBV-Like Stars in M33*
Watson P. Varricattu, *Near IR Spectroscopic Study of Late WC Stars Embedded in Dust Shells*
Sergey Mashchenko, *Automatic Shell Detection in the CGPS Survey*
Philippe Stée, *High Angular Resolution Optical Observations of Massive Stellar Winds*

2. Interaction of Stellar Winds from Different Evolutionary Phases

Joy S. Nichols, *The Correlation Between Ring Nebulae, Colliding Winds, and X-ray Emission*
Antonella Nota, *The η Car Structure in Optical and IR with HST*
Joseph Cassinelli*, *Binary Effects on the η Carinae Outburst*
Yves Grosdidier*, *Turbulent Status of the Ejected Nebula M1-67, Interface Between Clumpy Stellar Winds and the Interstellar Medium*
You-Hua Chu, *What Did WR Stars Do Before They Exploded as Supernovae?*
Roger Chevalier, *Supernovae and γ-ray Burst Explosions in the Winds of Massive Stars*
Vikram Dwarkadas*, *The Interaction of Supernova Shock Waves with Circumstellar Wind-Blown Bubbles*
Robert Link, *Photoionization Effects in the Circumstellar Nebulae Around the SN1987A Progenitor*

3. Intra-Wind Interactions of Hot Stellar Winds

Wolf-Rainer Hamann*, *Spectral Analyses of Wolf-Rayet Winds*
Sebastien Lépine, *Line Variability Induced by the Rotation of a Structured Wind*
Andrzej Niedzielski*, *The Structure of the Non-Uniform Wind of WR1*
Ulf Wessolowski*, *The RASS View of the Galactic Wolf-Rayet Stars*
Lydia Oskinova*, *X-ray Emission of a Single WR Star*
Isabelle Cherchneff, *Formation of Dust in Clumpy Winds Around Wolf-Rayet Stars*
Konstantin Bychkov*, *Relativistic Electron Acceleration in the Two-Phase Wind Model*

4. Applications

Paul Crowther*, *Ionized Nebulae as Probes of Lyman Continua from WR Stars*
Linda Smith*, *The Evolutionary History of LBVs from Ring Nebulae Studies*

Theory

1. Analytical

Artem Myasnikov*, *Physics of Wind Blown Bubbles: Models with Asymmetric Energy Dissipation*
Jean Zorec* & Anne Marie Hubert*, "Circumstellar Envelope Formation Mechanisms: Mass-Loaded Flows

2. Numerical Simulations

Garrelt Mellema*, *Interacting Winds and the Effects of WR Abundances*
Nir Shaviv, *Atmospheres Close to the Eddington Limit*
John Blondin*, *3D Simulations of Circumstellar Shells*

Other Related Objects

1. Planetary nebulae

Sun Kwok, *Interacting Winds and the Shaping of Planetary Nebulae*

Agnes Acker*, *Clumpy Winds from [WC] Nuclei of PNe*
Lars Koesterke, *The Driving Mechanism of the Clumped Winds of [WC] - CSPN*
John O'Connor*, *Hypersonic Outflows in PNe*

2. Novae

Tim O'Brien, *Interactions in Novae Ejecta*
Michael Shara, *Optically Resolved, Clumped Structures in Nova Ejecta*
Umanath Kamath*, *Infrared Signatures of Shocks in Nova Winds*

C. Colliding Winds in Massive Binaries

Diagnostics

1. General

1.1 Multi-wavelength

Diah Setia Gunawan, *Multiple-Wavelength Variations in Colliding Binaries*

1.2 Radio

Sean Dougherty, *Radio Studies of Colliding Wind Systems*
Karel A. van der Hucht, *Non-Thermal Radio Studies of WR Colliding Wind Binaries*

1.3 Infrared (dust)

Peredur Williams, *New Dust and Colliding Winds*
Yoann Le Teuff*, *Dust Formation in WR Stars: Case for Singles and Binaries*
John Monnier*, *Dust-Enshrouded WR Binaries in the IR and Radio*
Peter Tuthill*, *Pinwheels in the Sky*

1.4 Optical/Ultraviolet

Virpi Niemela, *Observations of Colliding Winds in Massive Binaries*
Grant Hill, *Modeling the Spectra of Colliding Winds*
Leonid Georgiev, *Influence of the Wind-Wind Collision Zone on Line Profile Variability*
Bahram Khalesseh, *Mass Transfer in Binaries*
Sergey Marchenko, *Interaction of a Clumpy WR Wind With an O Star Photosphere*
Cedric Foellmi, *First Results of a Systematic Search for Interacting WR-Binaries in the Magellanic Clouds*
Debra Wallace, *Searching for Close Visual Companions to WR Stars Using HST*
Wilhelm Seggewiss, *Long-Term Observations of WR Winds*
Gregor Rauw, *Searching for Colliding Wind Signatures in a Sample of O-Star Binaries*
Thomas Rivinius*, *Radiative Interaction in Be+SdO Binaries (ϕ Per and 59 Cyg)*
Hugues Sana, *Visible Spectroscopy of Colliding Wind Systems to be Observed with XMM*

1.5 X-ray

Steve Skinner*, *X-ray Spectroscopy Studies of Interacting Winds in WR Stars*
Ian Stevens, *New X-ray Results on Massive Stars from XMM and Chandra*
Anita Muecke, *Non-Thermal, High-Energy Emission from WR Binaries?*
Malcolm Coe*, *Winds in Massive X-Ray Binary Systems*

2. Individual Objects

2.1 Binaries with OB Stars

Philip Bennett, *The Massive Wind of the Eclipsing Binary VV Cephei (M2Ia + B0-2)*
Yael Nazé, *Line Profile Variability in the Massive Binary System HD 149404*

2.2 Luminous Blue Variables

Michael Corcoran, *Colliding Winds and η Carinae*
Augusto Damineli*, *η Carinae: Orbital Parameters*

2.3 Wolf-Rayet Stars

Andreas Kaufer*, *New Results on HD5980*
Jacques Breysacher, *High-Resolution Spectroscopy of HD5980*
Gloria Koenigsberger, *The Interacting Winds in HD5980*
Orsola De Marco*, *The γ Velorum O+WR Binary System*
Allan Willis*, *X-ray Emission from γ Velorum*
Richard White*, *Radio Emission from WR140*
Andy Pollock, *Latest X-ray News from WR140 and Friends*
Oksana Aleksandrova*, *Two-Phase Wind-Wind Interaction by Example of WR140*
Tim Harries*, *The Wind Geometry of the WC+O Binary WR137*
Igor Antokhin*, *Colliding Winds in CV Ser*
Siegfried Luehrs, *High Spectral Resolution Study of the Variable CIII 5696 Line in the Colliding Wind WC + O Binaries WR42 and WR79*
Hugues Demers, *Colliding Winds in the Quadruple System GP Cep*
Maria Contreras*, *New VLA Observations of WR 147*

Theory

1. Analytical

Vladimir Usov, *Colliding Winds in Hot Massive Binaries: Theory Meets Observations*
David Eichler*, *Analytic Solution for Collimated Winds*
Francis Wilkin*, *Models of Colliding Anisotropic Winds*
David Cohen*, *New X-ray Diagnostics for Colliding Winds*
Kenneth Gayley*, *Spectral Diagnostics of Radiative Braking*
Tom Bolton*, *Colliding Winds of Magnetic Stars*

2. Numerical Simulations

Rolf Walder, *Theoretical Considerations on Colliding Clumped Winds*
Doris Folini, *Theoretical Predictions for the Cold Part of the Colliding Wind Interaction Zone*
Svetozar Zhekov, *Colliding Stellar Wind Binaries: Theory vs. Observations - Do We Believe What We See?*
Julian Pittard, *Radiatively-Driven Colliding Stellar Winds*
Giuseppe Lanzafame*, *Role of Stellar Mass Ratio in Colliding Stellar Winds: 2D Numerical Models in the SPH Framework*

D. Personal Impressions of the Meeting

Ian Howarth

Henny Lamers

Massive Star Birth

Joint Discussion at the IAU General Assembly
Manchester, England
10 August 2000

Scientific Program

1. The Natal Environment: Molecular Clouds and Envelopes

J. Williams, *Structure and conditions in GMCs forming massive stars*
L. Mundy, *The circumstellar environment of embedded massive stars*
E. van Dishoeck, *Chemical variations in the envelopes around massive young stars*

2. The Non-Spherical Environment: Discs and Jets

J. Dyson, *MHD ionization fronts*
K. Menten, *Jets and outflows from massive protostars*
R. Cesaroni, *Disks and flows in high-mass Young Stellar Objects*

3. The Ionized Environment: UC HII and HII Regions

S. Lizano, *UC HII regions and massive star formation*
E. C hurchwell, *UC HII Regions and the earliest stages of massive star evolution*
Pierre Cox, *Dust in and around HII regions*

4. The Stellar Environment: Evolution and Observations

M. Hanson, *Spectroscopy of the ionizing sources in UC HII regions*
A. Maeder, *Formation of massive stars by growing accretion*
P. Conti, *Summary and "Where do we go from here?"*

P Cygni - 2000
400 Years of Progress

Armagh, Northern Ireland
21 - 23 August, 2000

Deadlines

Please return the declaration of interest before the end of April.

We foresee that in the event a registration fee is due, this will then have to be paid before 15th May in order to qualify for an early-registration reduction.

Scope of the Workshop

P Cygni was discovered on 18th August, 1600, while in outburst. Subsequent observations of the star have now covered a time span of four centuries. Especially the more frequent and accurate observations of the 20th century have revealed much about the nature of this enigmatic object. The 400th anniversary of the discovery of P Cygni is therefore the right time to discuss the progress made towards understanding this peculiar hypergiant, to ensure that the lessons learned from its study are not lost, and that these results can be applied to the study and understanding of similar objects and of the nature and evolution of massive stars in general.

Several recent developments would make a workshop where a critical review and analysis of historical and recent observational data as well as an evaluation of recent theoretical results are undertaken, a potentially fruitful exercise.

1. New photometric, spectroscopic and polarimetric data of the central star and its surrounding nebula are revealing hitherto unknown correlations that need to be confronted by theory.

2. Several recent studies have addressed the constancy or otherwise of P Cygni's and other LBVs' bolometric magnitude during their photometric and spectroscopic variations. A consensus opinion needs to be developed.

3. New opacities for stellar-interior studies have given credence to the idea that the instabilities in LBVs could be driven by an opacity-related mechanism. Calculations relevant to P Cygni's parameters are needed.

4. Irregular variations are being formulated through new mathematical methods; these need to be understood and compared with observational data.

5. Modern imaging and polarimetry are showing hitherto unknown details in the ejecta from previous outbursts and should give further clues to the star's evolution.

Scientific Program

Sunday 20th August: Arrival, Registration, Informal gathering

Monday 21st August:

09:00 - 12:30 : Opening, History, Observations of P Cygni and similar objects: photometry

14:00 - 17:30 : Observations (cont'd): stellar spectroscopy

Tuesday 22nd August:

09:00 - 12:30 : Observations of P Cygni's and similar nebulae

14:00 - 17:30 : Theory: pulsations, evolution Further similarities to other LBVs

Wednesday 23rd August:

09:00 - 12:00 : Integration, Future work, Conclusions

The workshop will conclude in time to allow participants in the Conference on "Eta Carinae and other mysterious stars" to travel to Copenhagen on Wednesday, 23rd August.

The Influence of Binaries on Stellar Population Studies

Brussels, Belgium
21-25 August 2000

Scientific Program

1. Observations of non-evolved binaries

1.a. Binary statistics in clusters and the field (J.C. Mermilliod)
1.b. Intermediate mass binaries (W. Van Rensbergen)
1.c. Massive close binaries (B. Mason)

2. Observations of evolved low mass and intermediate mass single stars and close binary components in stellar populations

2.a. White Dwarf binaries, Cataclysmic Variables, Super-soft X-ray binaries (Tom Marsh)
2.b. Algol-type binaries (Mercedes Richards)
2.c. Be stars: single and binary components (D. Gies)
2.d. Low mass X-ray binaries (F. Verbunt)

+3 contributed papers

3. Observations of evolved massive single stars and binary components in stellar populations

3.a. The observed WR population compared to other massive stars as function of metallicity (K.A. Van der Hucht)
3.b. High mass X-ray binaries and runaways(L. Kaper)
3.c. Starbursts, young clusters and binary signatures (T. Heckman)

+4 contributed papers

4. Pulsars and supernovae in stellar populations

4.a. Pulsars (F. Camilo)
4.b. Observations of SN: types and rates (E. Cappellaro/M. Turatto)

+3 contributed papers

5. Stellar evolution: theory versus observations

5.a. Evolution of low and intermediate mass single stars (P. Marigo)
5.b. Observations and theoretical interpretation of stellar winds in massive stars: present state (P. Crowther)
5.c. Evolution of massive single stars (A. Maeder)
5.d. Evolution of low and intermediate mass close binaries (P. Eggleton)
5.e. Evolution of massive close binaries (D. Vanbeveren)
5.f. The evolution of massive stars: final phases (N. Langer)

6. Population synthesis in regions of continuous star formation and in clusters or starbursts: theory versus observations

Different research groups discuss their theoretical population synthesis model with a realistic fraction of binaries and compare to observations with special emphasis on at least one of the following subclasses: Be stars, WDs, Algols, CVs, Super-soft X-ray sources, X-ray binaries, WR stars, starbursts, different types of SN and their rates, runaways, pulsars, gamma ray bursts.

6.a. C. Tout/O. Pols/ K. Hurley
6.b. J. Van Bever
6.c. L. Yungelson/G. Nelemans
6.d. H. Ritter/U. Kolb
6.e. P. Podsiadlowski
6.f. R. DiStefano/S. Rappaport
6.g. V. Kalogera
6.h. K. Postnov
6.i. S. McMillan/P. Hut/S. Portegies Zwart
6.j. C. Fryer
6.k. F. Rasio

This full day session will be closed with a general discussion on the previous models chaired by E.P.J. van den Heuvel.

7. The chemical evolution of galaxies: the role of binaries

7.a. Basic observations (S. Ryan) Progenitor models of Type Ia supernovae
7.b. L. Greggio
7.c. S. Tutukov

7.d. K. Nomoto
7.e. Final stellar evolutionary phases and stellar yields (F. Thielemann, to be confirmed)
7.f. Theoretical models of galactic chemical evolution (F. Matteucci)
7.g. The effect of binaries on chemical evolutionary models (E. De Donder)

+3 contributed papers

Each session includes a poster session. As can be noticed, there is room for additional oral contributed papers. If you want to present a contributed paper, include the abstract on the pre-registration form that can be found on the website with URL given below. The final decision will be made by the SOC after considering all abstracts.

For more information: http://homepages.vub.ac.be/∼wvanrens/bin_conference/
e-mail: dvbevere@vub.ac.be

Eta Carinae and Other Mysterious Stars
The Hidden Opportunities of Emission Line Spectroscopy

Hven, Sweden
24-26 August 2000

The Atomic Spectroscopy Group at the Department of Physics, Lund University, Sweden, is arranging a three day meeting on Tycho Brahe's island Hven in the sound between Sweden and Denmark. The meeting will focus on strange emission line spectra of various objects and Eta Carinae in particular. We want to bring together astrophysicists and atomic physicists working on these stars for a discussion of common spectroscopic problems. The meeting is sponsored by the Nobel Committee (The Royal Swedish Academy of Sciences), the Crafoord Foundation and the Royal Physiographic Society, Lund. Details about the meeting are found on the web site http://ferrum.fysik.lu.se/hven2000

The major topics of the meeting are:

Spectroscopy of Eta Carinae from X-rays to Radio; Questions, Problems and Challenges from Spectroscopy of Other Peculiar Emission Line Stars/Objects; Spectroscopic Connections - Similarities and Related Problems; Fluorescence and Radiative Processes.

We invite you to give an oral contribution or a poster paper on the following topics: New Spectroscopic Results on Eta Car and related objects; Photometry and Imaging of Eta Car; New Observations/Results on Peculiar emission line stars; Physical Processes Modelling - diagnostics, atmospheres, interiors and evolution.

Deadlines

The registration fee is 1000 SEK for early registration before 15 April, and 1500 SEK after this date (10 SEK = 1.2 USD).

For oral presentations, please, send in a brief abstract before April 15. Decisions about papers that are accepted for an oral presentation will be sent out before June 1. All abstracts of invited talks, oral contributions and posters should be submitted before May 15.

Scientific Program

Opening Remarks – Johansson and Davidson

I. Spectroscopy of Eta Carinae from X Rays to Radio

A. UV, optical to 1 micron:

* The central star	Hillier - confirmed
The inner ejecta < 2 arcsec	
Spectra of the Weigelt knots	Davidson - confirmed
The equatorial ejecta	Zethson - confirmed
The integral nebula and Homunculus	Gull - confirmed
Emission Line Variability	Rivinius - confirmed
The outer ejecta	Meaburn - confirmed; Weis - confirmed

B. Infrared TBD

C. X-Ray Corcoran - confirmed

D. Radio Cox - invited

E. Modelling and plasma diagnostics Hamann - confirmed

II. Questions, Problems and Challenges from Spectroscopy of Other Peculiar Emission Line Stars/Objects

A. Massive Stars

* Hot stars	Stahl - confirmed
Cool Hypergiants	Humphreys - confirmed
Luminous hot stars near the galactic center	Najarro - confirmed

B. Symbiotic Stars TBD

C. Cool Star Chromospheres and the Sun Linsky - confirmed

D. Young Stellar Objects Gahm - confirmed

III. Spectroscopic Connections - similarities and related problems

Optical spectra of objects with enhanced emission lines	Viotti - confirmed
A comparison of the emission spectrum of Eta Car with similar stars	Wallerstein - confirmed
The OI8446, FeII8490, FeII9997 and Paschen lines in hot luminous stars	Damineli - confirmed
Invited Review on common problems and challenges these different objects present	Feast - confirmed

IV. Fluorescence and radiative processes

Radiative Transfer	Ferland - confirmed
Fluorescence(general)	Johansson - confirmed
Fluorescence (Ramann scattering)	Schmid - confirmed
Lasering	Letokhov - confirmed

V. Summing Up Final Remarks de Jager - invited

Posters and Oral Contributions:

New Spectroscopic Results on Eta Car and related objects
Photometry and Imaging of Eta Car
New Observations/Results on Peculiar emission line stars
Physical Processes and Modelling - diagnostics, atmospheres, interiors and evolution

Contact

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