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Accepted Papers

High resolution radio observations of the colliding-wind binary WR 140

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Milli-arcsecond resolution Very Long Baseline Array (VLBA) observations of the archetype WR+O star colliding-wind binary (CWB) system WR 140 are presented for 23 epochs between orbital phases 0.74 and 0.97. At 8.4 GHz, the emission in the wind-collision region (WCR) is clearly resolved as a bow-shaped arc that rotates as the orbit progresses. We interpret this rotation as due to the O star moving from SE to approximately E of the WR star, which leads to solutions for the orbit inclination of 122 deg ±5 deg, the longitude of the ascending node of 353 deg ±3 deg, and an orbit semi-major axis of 9.0±0.5 mas. The distance to WR 140 is determined to be 1.85±0.16 kpc, which requires the O star to be a supergiant. The inclination implies the mass of the WR and O star to be 20±4 $M_\odot$ and 54±10 $M_\odot$ respectively. We determine a wind-momentum ratio of 0.22, with an expected half-opening angle for the WCR of 63 deg, consistent with 65 deg ±10 deg derived from the VLBA observations. Total flux measurements from Very Large Array (VLA) observations show the radio emission from WR 140 is

very closely the same from one orbit to the next, pointing strongly toward emission, absorption and cooling mechanism(s) that are controlled largely by the orbital motion. The synchrotron spectra evolve dramatically through the orbital phases observed, exhibiting both optically thin and optically thick emission. We discuss a number of absorption and cooling mechanisms that may determine the evolution of the synchrotron spectrum with orbital phase.

Submitted to ApJ
Preprints from sean.dougherty@nrc.ca
or on the web at http://www.drao.nrc.ca/∼smd/preprint/wr140_ms_revised.pdf

Forty eclipsing binaries in the Small Magellanic Cloud: fundamental parameters and Cloud distance

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We have conducted a programme to determine the fundamental parameters of a substantial number of eclipsing binaries of spectral types O and B in the Small Magellanic Cloud. New spectroscopic data, obtained with the two-degree-field multi-object spectrograph on the 3.9-m Anglo-Australian Telescope, have been used in conjunction with photometry from the Optical Gravitational Lens Experiment (OGLE-II) database of SMC eclipsing binaries. Previously, we reported results for 10 systems; in this second and concluding paper we present spectral types, masses, radii, temperatures, surface gravities and luminosities for the components of a further 40 binaries. The full sample of 50 OB-type eclipsing systems is the largest single set of fundamental parameters determined for high-mass binaries in any galaxy. Each system provides a primary distance indicator. We find a mean distance modulus to the SMC of 18.91+/-0.03+/-0.1 (internal and external uncertainties; D=60.6+/-1.0 kpc). This value represents one of the most precise available determinations of the distance to the SMC.

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Polarimetric line profiles for scattering off rotating disks

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We predict polarimetric line profiles for scattering off rotating disks using a Monte Carlo technique. We have discovered that there is a marked difference between scattering of line emission by a disk that reaches the stellar surface, and a disk with an inner hole. For the case with an inner hole, we find *single* position-angle rotations, similar to those predicted by analytic models. For the case of an undisrupted disk, we find *double* rotations in the position angle – an effect not reported before. We show that this new effect is due to the finite-sized star interacting with the disk's rotational velocity field. Since a gradual increase of the hole size transforms the double rotations smoothly back into single ones – as the line emission object approaches that of a point source – our models demonstrate

the diagnostic potential of line polarimetry in determining not only the disk inclination, but also the size of the disk inner hole.

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HST/NICMOS Variability Study of Massive Stars in the Young Dense Galactic Starburst NGC 3603

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We have used the relatively long data-string of the 1997-99 NICMOS focus tests on NGC 3603 to extract ∼J-band light curves for several hundred stars in the cluster core. Given the relatively modest photometric precision ($\sigma(J) \geq 0.05$ mag), we were able to isolate only a half-dozen variable candidates with peak-to-valley amplitudes above ∼0.2 mag. One of the variables is one of the two outstandingly brightest cluster members, A1, located in the very dense cluster center. A1 shows double eclipses on each orbital cycle, with the same period (P = 3.7724d) as found previously and independently in unresolved ground-based radial-velocity variations of the WR emission-component in the central core of NGC 3603. Very rough best estimates for the masses of the components of A1 are in the range 30 - 90 $M_\odot$ for the brighter and more massive H-rich WR component (WN6ha) and 25 - 50 $M_\odot$ for its assumed O-star companion. A more detailed study is urgently needed, given the potential for this extremely luminous system to harbor the most massive main-sequence star ever "weighed". Another variable, HST12, escaped the original search based on larger-than-average standard deviation. It is a probable field-star eclipser with a moderately long period.

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The Stellar Content of Obscured Galactic Giant HII Regions V: G333.1–0.4

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We present high angular resolution near–infrared images of the obscured Galactic Giant HII (GHII) region G333.1–0.4 in which we detect an OB star cluster. For G333.1–0.4, we find OB stars and

other massive objects in very early evolutionary stages, possibly still accreting. We obtained K–band spectra of three stars; two show O type photospheric features, while the third has no photospheric features but does show CO 2.3 μm band–head emission. This object is at least as hot as an early B type star based on its intrinsic luminosity and is surrounded by a circumstellar disc/envelope which produces near infrared excess emission. A number of other relatively bright cluster members also display excess emission in the K–band, indicative of disks/envelopes around young massive stars. Based upon the O star photometry and spectroscopy, the distance to the cluster is 2.6 $\pm$ 0.4 kpc, similar to a recently derived kinematic (near side) value. The slope of the K–band luminosity function is similar to those found in other young clusters. The mass function slope is more uncertain, and we find $-1.3 \pm 0.2 < \Gamma < -1.1 \pm 0.2$- for stars with M $>$ 5 $M_\odot$ where the upper an lower limits are calculated independently for different assumptions regarding the excess emission of the individual massive stars. The number of Lyman continuum photons derived from the contribution of all massive stars in the cluster is $0.2 \times 10^{50}\ s^{-1} < NLyc < 1.9 \times 10^{50}\ s^{-1}$. The integrated cluster mass is $1.0 \times 10^3\ M_\odot < M_{cluster} < 1.3 \times 10^3\ M_\odot$.

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The Absorption Spectrum of High-Density Stellar Ejecta in the Line-of-Sight to Eta Carinae

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Using the high dispersion NUV mode of the Space Telescope Imaging Spectrograph (STIS) aboard the Hubble Space Telescope (HST) to observe Eta Carinae, we have resolved and identified over 500 sharp, circumstellar absorption lines of iron-group singly-ionized and neutral elements with ≈20 velocity components ranging from -146 km/s to -585 km/s. These lines are from transitions originating from ground and metastable levels as high as 40,000 cm^{-1} above ground. The absorbing material is located either in dense inhomogeneities in the stellar wind, the warm circumstellar gas immediately in the vicinity of Eta Carinae, or within the cooler foreground lobe of the Homunculus. We have used classical curve-of-growth analysis to derive atomic level populations for FeII at −146 km/s and for TiII at −513 km/s. These populations, plus photoionization and statistical equilibrium modeling, provide electron temperatures, T_e, densities, n_H, and constraints on distances from the stellar source, r. For the −146 km/s component, we derive T_e = 6400 K, $n_H \geq 10^7 - 10^8$ cm^{-3}, and d ≈ 1300 AU. For the −513 km/s component, we find a much cooler temperature, T_e= 760 K, with $n_H \geq 10^7$ cm^{-3}, we estimate d≈ 10,000 AU. The large distances for these two components place the absorptions in the vicinity of identifiable ejecta from historical events, not near or in the dense wind of Eta Carinae. Further analysis, in parallel with obtaining improved experimental and theoretical atomic data, is underway to determine what physical mechanisms and elemental abundances can explain the large number of strong circumstellar absorption features in the spectrum of Eta Carinae.

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A Revised Geometry for the Magnetic Wind of θ^1 Orionis C

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The star θ^1 Orionis C (O6–7 V) is often cited as a hot analog of Bp variables because its optical and UV line and X-ray continuum fluxes modulate over the magnetic/rotational period. In this circumstance, one expects emission and absorption components of the UV resonance lines to vary as a flattened magnetosphere co-rotates with the star. In this paper we re-examine the detailed velocity behavior of several strong UV lines. Whereas past work has focused on variations of the full profiles, we find that the blue and red wings of the C 4 and N 5 resonance lines exhibit anticorrelated modulations. These appear as absorption excesses at large blueshifts, and flux elevations at moderate redshifts at the edge-on phase ϕ=0.5. No rest-frame absorption features, which are the typical signatures of cool, static disks surrounding Bp stars, can be detected at any phase.

We suggest that this behavior is caused by two geometrically distinct components of the wind, which are defined by the relationship between the extent of a magnetic loop and the local Alfven radius. Streams on field lines opening outside this radius are first channeled toward the magnetic equator, but after reaching the Alfven radius they are forced outward by radiative forces, eventually to become an expanding radial outflow. This wind component causes blueshifted absorption as the co-rotating magnetic equatorial plane crosses the observer's line of sight (ϕ= 0.5). The geometry of the inner component requires a more complicated interpretation. Wind streams first follow closed loops and collide at the magnetic equator with counterpart streams from the opposite pole. There they coalesce and fall back to the star along their original field lines. The high temperatures in these falling condensations cause the redshifted emission. The rapid circulation of these flows is likely the reason for the absence of signatures of a cool disk (e.g., zero-velocity absorptions at $\phi \sim 0.5$) in the strong UV lines.

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The spectrum of the very massive binary system WR 20a (WN6ha + WN6ha): fundamental parameters and wind interactions

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We analyse the optical spectrum of the very massive binary system WR 20a (WN6ha + WN6ha). The most prominent emission lines, Hα and He II λ 4686, display strong phase-locked profile variability. From the variations of their equivalent widths and from a tomographic analysis, we find that part of

the line emission probably arises in a wind interaction region between the stars. Our analysis of the optical spectrum of WR 20a indicates a reddening of $A_V \simeq 6.0$ and a distance of ~ 7.9 kpc, suggesting that the star actually belongs to the open cluster Westerlund 2. The location of the system at ~ 1.1 pc from the cluster core could indicate that WR 20a was gently ejected from the core via dynamical interactions. Using a non-LTE model atmosphere code, we derive the fundamental parameters of each component: $T_{\rm eff} = 43\,000 \pm 2000$ K, $\log L_{\rm bol}/{\rm L}_\odot \simeq 6.0$, $\dot{M} = 8.5 \times 10^{-6}\,{\rm M}_\odot\,{\rm yr}^{-1}$ (assuming a clumped wind with a volume filling factor $f = 0.1$). Nitrogen is enhanced in the atmospheres of the components of WR 20a, while carbon is definitely depleted. Finally, the position of the binary components in the Hertzsprung-Russell diagram suggests that they are core hydrogen burning stars in a pre-LBV stage and their current atmospheric chemical composition probably results from rotational mixing that might be enhanced in a close binary compared to a single star of same age.

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Hydrodynamic model atmospheres for WR stars: Self-consistent modeling of a WC star wind

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We present the first non-LTE atmosphere models for WR stars that incorporate a self-consistent solution of the hydrodynamic equations. The models take iron-group line-blanketing and clumping into account, and compute the hydrodynamic structure of a radiatively driven wind consistently with the non-LTE radiation transport in the co-moving frame. We construct a self-consistent wind model that reproduces all observed properties of an early-type WC star (WC5). We find that the WR-type mass-loss is initiated at high optical depth by the so-called 'Hot Iron Bump' opacities (FeIX XVI). The acceleration of the outer wind regions is due to iron-group ions of lower excitation in combination with C and O. Consequently, the wind structure shows two acceleration regions, one close to the hydrostatic wind base in the optically thick part of the atmosphere, and another farther out in the wind. In addition to the radiative acceleration, the 'Iron Bump' opacities are responsible for an intense heating of deep atmospheric layers. We find that the observed narrow O VI emission lines in the optical spectra of WC stars originate from this region. From their dependence on the clumping factor we gain important information about the location where the density inhomogeneities in WR-winds start to develop.

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Evolutionary Stellar Population Synthesis at High Spectral Resolution: Optical Wavelengths.

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We present the single stellar population (SSP) synthesis results of our new synthetic stellar atmosphere models library with a spectral sampling of 0.3 Å, covering the wavelength range from 3000 Å to 7000Å for a wide range of metallicities (twice solar, solar, half and 1/10 solar). The stellar library is composed of 1650 spectra computed with the latest improvements in stellar atmospheres. In particular it incorporates non-LTE line-blanketed models for hot ($T_{eff} \geq 27500$ K) and LTE line-blanketed models (Phoenix) for cool (3000 K $\leq T_{eff} \leq$ 4500 K) stars. Because of the high spectral resolution of this library, evolutionary synthesis models can be used to predict the strength of numerous weak absorption lines, and the evolution of the profiles of the strongest lines over a wide range of ages. The SSP results have been calculated for ages 1 Myr to 17 Gyr using the stellar evolutionary provided by the Geneva and Padova-tracks groups. For young stellar populations, our results have a very detailed coverage of high-temperature stars with similar results for Padova and Geneva isochrones. For intermediate and old stellar populations, our results, once degraded to a lower resolution, are similar to the ones obtained by other groups apart from limitations imposed by the stellar evolutionary physics. The limitations and advantages of our library for the analysis of integrated populations are described. The full set of the stellar library and the evolutionary models are available here for retrieval or on request from authors.

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Preprints from `rosa@iaa.es, mcs@iaa.es`
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Models results available from the URL `http://www.iaa.es/∼rosa/` (ascii table) and `http://ov.inaoep.mx/` (VO table)

Evolutionary Stellar Population Synthesis at High Spectral Resolution: Optical Wavelengths.

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We present a library of 1654 high-resolution stellar spectra, with a sampling of 0.3 Å and covering the wavelength range from 3000 Å to 7000 Å. The library was computed with the latest improvements in stellar atmospheres, incorporating non-LTE line-blanketed models for hot, massive ($T_{eff} \geq 27500$ K) and line-blanketed models for cool (3000 K $\leq$ T_eff $\leq$ 4500 K) stars. The total coverage of the grid is 3000 K $\leq T_{eff} \leq$ 55000 K and 0.5 $\leq$ log g $\leq$ 5.5, for four chemical abundance values: twice solar, solar, half solar and 1/10 solar. Evolutionary synthesis models using this library are presented in a companion paper. We tested the general behavior of the library by calculating and comparing

equivalent widths of numerous H and HeI lines, and some of the commonly used metallic indices. We also compared the library with the empirical libraries STELIB and Indo-US. The full set of the synthetic stellar spectra is available here for retrieval, or on request from authors.

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or on the web at htpp://www.iaa.es/∼rosa/
Models results available from the URL http://www.iaa.es/∼rosa/ and
http://www.astro.iag.usp.br/∼lucimara/library.html (ascii table) and
http://ov.inaoep.mx/ (VO table)

N88: The physical properties of a compact star forming region and its neighbourhood in the SMC

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This second in a series of papers on the conspicuous compact HII region N88A in the Small Magellanic Cloud emphasizes the properties of the H_2 emission as well as of the surrounding stellar content of the entire Henize region N88. Using VJK photometry and stellar evolutionary models our analysis of N88 reveals a miscellaneous population of evolved stars of low and intermediate masses (1.2-8 $M_\odot$) in an age range of 40 Myr to 6 Gyr. The majority of these stars are found in the cluster HW 82 which also contains several main sequence stars. A_V in N88A is revisited using near-IR Pδ, Pγ and Pβ Paschen emission lines. Spectroscopic measurements of the H_2 emission in Z, J, H and K bands allow, in conjunction with measurements in the visible, a full spectral coverage from 0.37μm to 2.45μm. Long slit spectroscopy through N88 and the nebulosity to the east clearly distinguishes the ionization zone in N88 characterized by H I and He I emission with pure H_2 emission clearly delineated in the cloud nearby. The principal excitation mechanism for H_2 is through fluorescent excitation in a photodissociation region associated with N88A.

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The ionization structure of early-B supergiant winds

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We present empirically determined ionization conditions for the winds of 106 luminous B0 to B5 stars observed by *IUE*. The UV wind lines are modelled to extract products of mass-loss rates times ionization fractions ($M_\odot$ yr^{-1} $q_i(w)$, where $w = v/v_\infty$) for N V, C IV, Si IV, Si III, Al III and C II. We describe the general behaviour of the $M_\odot$ yr^{-1} $q_i(w)$ and their ratios, demonstrating that the wind ionization *increases* with distance from the star, contrary to recent findings for O star winds. Using empirical mass-loss rates (from Hα observations) and model prescriptions, we derive mean $q_i(w)$ values integrated over the wind, $\langle q_i \rangle$. These $\langle q_i \rangle$ are quite small, never exceeding 15% for Al III or 2% for

Si IV. This is surprising, since the $\langle q_i \rangle$ for these ions clearly peak within the observed spectral range. We conclude that the low $\langle q_i \rangle$ arise because the $\langle \mathrm{M}_\odot\ \mathrm{yr}^{-1}\, q_i \rangle$ are underestimated by the wind models, which assume that the outflows are smooth when they are, in fact, highly structured.

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VLT-UVES observations of the Balmer line variations of η Carinae during the 2003 spectroscopic event

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We present high spectral resolution echelle observations of the Balmer line variations during the 2003.5 "spectroscopic event" of η Carinae. Spectra have been recorded of both η Carinae and the Homunculus at the FOS4 position in its SE lobe. This spot shows a reflected stellar spectrum which is less contaminated by nebular emission lines than ground-based observations of the central object itself. Our observations show that the spectroscopic event is much less pronounced at this position than when seen directly on η Car using HST/STIS. Assuming that the reflected spectrum is indeed latitude dependent this indicates that the spectral changes during the event seen pole-on (FOS4) are different from those closer to the equator (directly on the star). In contrast to the spectrum of the star, the scattered spectrum of FOS4 always shows pronounced P Cygni absorption with little variation across the "spectroscopic event". After that event an additional high-velocity absorption component appears. The emission profile is more peaked at FOS4 and consists of at least 3 distinct components, of which the reddest one shows the strongest changes through the event. The data seem to be compatible with changes in latitudinal wind structure of a single star, with or without the help of a secondary star, or the onset of a shell ejection during the spectroscopic event.

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SN 2002kg – the brightening of LBV V37 in NGC 2403

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SN2002kg is a type IIn supernova, detected in October 2002 in the nearby spiral galaxy NGC 2403. We show that the position of SN2002kg agrees within the errors with the position of the LBV V37. Ground based and HST ACS images however show that V37 is still present after the SN2002kg event. We compiled a lightcurve of V37 which underlines the variablity of the object, and shows that SN2002kg

was the brightening of V37 and not a supernova. The recent brightening is not a giant eruption, but more likely part of an S Dor phase. V37 shows strong H_α +[N II] emission in recent images and in the SN2002kg spectrum, which we interprete as the signature of the presence of an LBV nebula. A historic spectrum lacks emission, which may hint that we are witnessing the formation of an LBV nebula.

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Kinematical Structure of Wolf-Rayet Winds. II. Internal Velocity Scatter in WN Stars

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The shortward edge of the absorption core velocities – $v_{\rm black}$ as determined from low resolution archived IUE spectra from the INES database are presented for three P Cygni profiles of NV 1240, HeII 1640 and NIV 1720 for 51 Galactic and 64 LMC Wolf-Rayet stars of the WN subtype. These data, together with $v_{\rm black}$ of CIV 1550 line presented in Niedzielski & Skórzyński (2002) are discussed. Evidences are presented that $v_{\rm black}$ of CIV 1550 rarely displays the largest wind velocity among the four lines studied in detail and therefore its application as an estimator of the terminal wind velocity in WN stars is questioned. An average $v_{\rm black}$ of several lines is suggested instead but it is pointed out that $v_{\rm black}$ of HeII 1640 usually reveals the highest observable wind velocity in Galactic and LMC WN stars. It is shown that the stratification strength decreases from WNL to WNE stars and that for WNL stars there exists a positive relation between $v_{\rm black}$ and the Ionization Potential. The velocity scatter between $v_{\rm black}$ obtained from different UV lines is found to correlate well with the X-ray luminosity of single WN stars (correlation coefficient R=0.86 for the data obtained from the high resolution IUE spectra) and therefore two clumpy wind models of single WN stars are presented that allow the velocity scatter to preserve up to very large distances from the stellar surface ($r \approx 500$ – $1000 R_*$). These models are used to explain the specific features of single WN stars like broad absorption troughs of strong lines having different $v_{\rm black}$, X-ray fluxes, IR/radio continua and stratification relations.

Accepted by Acta Astronomica
Preprints from aniedzi@astri.uni.torun.pl

A layered model for non-thermal radio emission from single O stars

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We present a model for the non-thermal radio emission from bright O stars, in terms of synchrotron

emission from wind-embedded shocks. The model is an extension of an earlier one, with an improved treatment of the cooling of relativistic electrons. This improvement limits the synchrotron-emitting volume to a series of fairly narrow layers behind the shocks. We show that the width of these layers increases with increasing wavelength, which has important consequences for the shape of the spectrum. We also show that the strongest shocks produce the bulk of the emission, so that the emergent radio flux can be adequately described as coming from a small number of shocks, or even from a single shock.

A single shock model is completely determined by four parameters: the position of the shock, the compression ratio and velocity jump of the shock, and the surface magnetic field. Applying a single shock model to the O5 If star Cyg OB2 No. 9 allows a good determination of the compression ratio and shock position and, to a lesser extent, the magnetic field and velocity jump.

Our main conclusion is that strong shocks need to survive out to distances of a few hundred stellar radii. Even with multiple shocks, the shocks needed to explain the observed emission are stronger than predictions from time-dependent hydrodynamical simulations.

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Preprints from `sven.vanloo@oma.be`
or on the web at `http://fr.arxiv.org/abs/astro-ph/0412466`

Near-infrared identification of the counterpart to X1908+075: a new OB-supergiant X-ray binary

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We report the near-infrared (near-IR) identification of the likely counterpart to X1908+075, a highly absorbed Galactic X-ray source recently suspected to belong to the rare class of OB supergiant-neutron star binary systems. Our JHK_s-band imaging of the field reveals the existence within the X-ray error boxes of a near-IR source consistent with an early-type star lying at $d{\sim}7$ kpc and suffering $A_V{\sim}16$ mag of extinction, the latter value being in good agreement with the hydrogen column density derived from modelling of the X-ray spectrum. Our follow-up, near-IR spectroscopic observations confirm the nature of this candidate and lead to a late O-type supergiant classification, thereby supporting the identification of a new Galactic OB-supergiant X-ray binary.

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Preprints from `thierry@ster.kuleuven.ac.be`
or on the web at `http://www.ster.kuleuven.ac.be/~thierry/ drafts.html`

Submitted Papers

Atmospheric NLTE-Models for the Spectroscopic Analysis of Blue Stars with Winds
II. Line-Blanketed Models

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We present new or improved methods for calculating NLTE, line-blanketed model atmospheres for hot stars with winds (spectral types A to O), with particular emphasis on a *fast performance*. These methods have been implemented into a previous, more simple version of the model atmosphere code FASTWIND and allow to spectroscopically analyze rather large samples of massive stars in a reasonable time-scale, using state-of-the-art physics. Although this updated version of the code has already been used in a number of recent investigations, the corresponding methods have not been explained in detail so far, and no rigorous comparison with results from alternative codes has been performed. This paper intends to address both topics.

In particular, we describe our (partly approximate) approach to solve the equations of statistical equilibrium for those elements which are primarily responsible for line-blocking and blanketing, as well as an approximate treatment of the line-blocking itself, which is based on a simple statistical approach using suitable means for line opacities and emissivities. Both methods are validated by specific tests. Furthermore, we comment on our implementation of a consistent temperature structure.

In the second part, we concentrate on a detailed comparison with results from those two codes which have been used in alternative spectroscopical investigations, namely CMFGEN and WM-Basic. All three codes predict almost identical temperature structures and fluxes for $\lambda > 400$ Å, whereas at lower wavelengths a number of discrepancies are found. Particularly in the He II continua, where fluxes and corresponding numbers of ionizing photons react extremely sensitively to subtle differences in the models, we consider any uncritical use of these quantities (e.g., in the context of nebula diagnostics) as being dangerous. Optical H/He lines as synthesized by FASTWIND are compared with results from CMFGEN, obtaining a remarkable coincidence, except for the He I, singlets in the temperature range between 36,000 to 41,000 K for dwarfs and between 31,000 to 35,000 K for supergiants, where CMFGEN predicts much weaker lines. Consequences due to these discrepancies are discussed.

Finally, suggestions are presented how to adequately parameterize model-grids for hot stars with winds, with only one additional parameter compared to standard grids from plane-parallel, hydrostatic models.

Submitted to A&A

Preprints from uh101aw@usm.uni-muenchen.de
or on the web at http://www.usm.uni-muenchen.de/people/puls/Puls.html

In Proceedings

Radio emission from WR140

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Milliarcsecond resolution Very Long Baseline Array (VLBA) observations of the archetype WR+O star colliding-wind binary (CWB) system WR 140 have been obtained at 23 epochs between orbital phases 0.74 to 0.97. The emission in the wind-collision region (WCR) is resolved as a bow-shaped arc which rotates as the orbital phase progresses. This rotation provides for the first time the inclination of the orbit ($122^\circ \pm 5^\circ$), the longitude of the ascending node ($353^\circ \pm 3^\circ$), and the orbit semi-major axis (9.0±0.5 mas). The implied distance is 1.85±0.16 kpc, which requires the O star to be a supergiant, and leads to a wind-momentum ratio of 0.22. Quasi-simultaneous Very Large Array (VLA) observations show the synchrotron spectra evolve dramatically through the orbital phases observed, exhibiting both optically thin and optically thick emission. The optically thin emission maintains a spectral index of -0.5, as expected from diffusive shock acceleration.

Contributed paper to "Massive Stars and Interacting Binaries" (A.J.F. Moffat & N. St-Louis (eds.))

Preprints from `sean.dougherty@nrc.ca`
or on the web at `http://www.drao.nrc.ca/~smd/preprint/msib_dougherty.pdf`

NGC 6231: X-ray properties of the early-type star population

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Based on a deep XMM-Newton observation of the young open cluster NGC 6231, we derive the main X-ray properties of its early-type star population. Among the 610 X-ray sources detected in the field, 42 are associated with early-type stars. We investigate their $L_{\rm X}/L_{\rm bol}$ relationship and we confirm the clear dichotomy between O- and B-type stars. The cut-off line between the two behaviours occurs at $L_{\rm bol} \sim 10^{38}\,{\rm erg\,s^{-1}}$ as previously proposed by Berghöfer et al. (1997). The distinction between single and binary stars is not clear cut, except for the colliding wind system HD 152248. The X-ray detected B-stars in NGC 6231 appear to be more luminous than predicted from the Berghöfer et al. relation. Though this suggests a bimodal distribution of the B-star X-ray emission, we caution however that these results might be biased by detection limits. Finally we investigate the X-ray variability of the detected sources and we find that about 40% of the X-ray emitters in the field of view present consistent signs of variability in the EPIC instruments. This fraction is much larger than previously thought. About one third of the early-type stars population, either singles or binaries, further shows

variability. These variations do not seem to be exclusively related to binarity and could thus not be systematically interpreted in the framework of a wind-wind collision phenomenon.

To appear in *Massive Stars in Interacting Binaries*, **ASP. Conf. Ser., Eds. A.F.J. Moffat & N. St-Louis**
Preprints from sana@astro.ulg.ac.be
or on the web at http://vela.astro.ulg.ac.be/Preprints/P97/index.html

New colliding wind massive binaries

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We report on the recent discovery of two new massive binary systems: WR 20a and Cyg OB2 #8A. For both systems, we briefly present the orbital solutions and we discuss the strong phase-locked line profile variability of the Hα and HeII λ 4686 lines for WR 20a, and the HeII λ 4686 line in the case of Cyg OB2 #8A. In both cases, we show that the profile variability reveals a signature of a wind interaction. The prospects for future high-energy observations are also discussed.

To appear in the Proceedings of the conference on *Massive Stars in Interacting Binaries*, **eds A.F.J. Moffat & N. St-Louis (Canada, August 2004)**
Preprints from debecker@astro.ulg.ac.be
or on the web at http://vela.astro.ulg.ac.be/Preprints/P98/index.html

Models of the Radio Emission from Colliding-Wind Binaries

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The collision of the hypersonic winds in early-type binaries is a natural site for particle acceleration via the first-order Fermi mechanism. Non-thermal radio emission is detected in many such systems, and is spatially resolved in several nearby binaries. These objects allow us to probe the nature of particle acceleration at significantly higher mass, radiation, and magnetic field energy densities than similar observations of supernova remnants allow. We present recently developed theoretical models of the radio emission from colliding-wind binaries (CWBs). Comparison with observations reveals that of order 1 per cent of the total shock energy is used to accelerate electrons to relativistic energies in WR 147. Such an unexpectedly high value has consequences for the thermal X-ray emission from CWBs. Our latest work incorporates inverse-Compton cooling of the relativistic electrons, and should yield deeper insight into the mechanisms responsible for the observed radio emission in WR 140.

To appear in the proceedings of Massive Stars in Interacting Binaries, Sacacomie, 16-20 August 2004
Preprints from jmp@ast.leeds.ac.uk

Radio behavior of four southern non-thermal O-type stars

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We have conducted high resolution continuum observations at 1.4 and 2.4 GHz with the Australia Telescope Compact Array, towards the four southern Of stars: CD-47 4551, HD 93129A, HD 124314, and HD 150136. All stars have been detected at the two frequencies. HD 93129A – the only O2 I star catalogued so far, and in a double system –, has also been observed at 17.8 and 24.5 GHz. Its radio spectrum, complemented with previous observations at higher frequencies, is analyzed here. The interpretation yields the estimate of its mass loss rate, and a non-thermal spectral index of radiation coming from a putative colliding wind region. The synchrotron and corresponding inverse Compton luminosities are derived.

Submitted to PASP Conference Series

Preprints from pbenaglia@fcaglp.unlp.edu.ar

or on the web at astro-ph/0410547

X-ray Gyrations of η Car, *or* Is Presence of Evidence Evidence of Presence?

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We review the properties of the variable X-ray emission from the extremely massive star Eta Car concentrating on the last X-ray minimum, and briefly consider the possible role of a binary companion star on the observational properties of the system.

To Appear in the Proceedings of the Conference on "Massive Stars in Interacting Binaries", held Aug. 16-20 2004, Quebec, Canada

Preprints from corcoran@barnegat.gsfc.nasa.gov

or on the web at
lheawww.gsfc.nasa.gov/users/corcoran/etacar/2003.5/resources/reports/papers_presentations.html

XMM-Newton Observations of the 2003 X-ray Minimum of η Carinae

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The XMM-Newton X-ray observatory took part in the multi-wavelength observing campaign of the massive, evolved star η Carinae in 2003 during its recent X-ray minimum. This paper reports on the results of these observations, mainly from the aspect of spectral change. Hard X-ray emission from the point source of η Carinae was detected even during the minimum. During the minimum the observed flux above 3 keV was $\sim 3\times10^{-12}$ ergs cm^{-2} s^{-1}, which is about one percent of the flux before the minimum. Changes in the spectral shape revealed two X-ray emission components in the central point source. One component is non-variable and has relatively cool plasma of $kT \sim 1$ keV and moderate absorption, $N_H \sim 5\times10^{22}$ cm^{-2}. The plasma is probably located far from the star, possibly produced by the high speed polar wind from η Carinae. The other high temperature component has $kT \sim 5$ keV and is strongly variable. This component shows an increase in the apparent column density from 5×10^{22} cm^{-2} to 2×10^{23} cm^{-2}, probably originating near the heart of the binary system. These changes in $N_{\rm H}$ were smaller than expected if the minimum is produced solely by an increase of hydrogen column density. The X-ray minimum seems to be dominated by a decrease of the apparent emission measure, suggesting that the brightest part of the X-ray emitting region is completely obscured during the minimum in the form of an eclipse. A "partial covering" model might explain the residual emission seen during the minimum.

Conference proceeding of the workshop "Massive Stars in Interacting Binaries" held in Quebec Canada (16-20 Aug, 2004). The proceeding paper is also submitted to Astro-ph/0411271
For preprints, contact kenji@milkyway.gsfc.nasa.gov
The preprint is also available from
lheawww.gsfc.nasa.gov/users/corcoran/eta_car/2003.5/resources/reports/papers_presentations.html - 524 kB

Diagnostics of Disks Around Hot Stars

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We discuss three different observational diagnostics related to disks around hot stars: absorption line determinations of rotational velocities of Be stars; polarization diagnostics of circumstellar disks; and X-ray line diagnostics of one specific magnetized hot star, θ^1 Ori C. Some common themes that emerge from these studies include (a) the benefits of having a specific physical model as a framework for interpreting diagnostic data; (b) the importance of combining several different types of observational diagnostics of the same objects; and (c) that while there is often the need to reinterpret traditional diagnostics in light of new theoretical advances, there are many new and powerful diagnostics that are, or will soon be, available for the study of disks around hot stars.

To appear in the proceedings of *The Nature and Evolution of Disks Around Hot Stars*, **eds. R. Ignace and K. Gayley, ASP Conf. Series**
or on the web at http://astro.swarthmore.edu/∼cohen/Papers/Cohen_ETSU_diagfocus.pdf

News

Top 10 Problems on Massive Stars

Cássio Barbosa[1] **and Donald Figer**[2]

[1] IAG-USP [2] STScI

We have asked a number of researchers to compile their lists of the top 10 problems in the field of massive stars. This paper is a compilation of these lists. We attempted to survey observers and theorists and those studying all evolutionary stages in the lives of massive stars. Each list reflects the proposer's personal point of view, but hopefully, this compilation will motivate new young astronomers and begin a new series of discussion.

On the web at astro-ph/0408491

Meetings

Workshop on Stars with the B[e] Phenomenon
10 - 16 July 2005
Strandhotel Seeduyn, Island of Vlieland, The Netherlands

Contact:

e-mail: M.Kraus@phys.uu.nl
http://www.astro.uu.nl/∼kraus/b-e-conf/

Important deadlines:

Application for financial support : February 15, 2005
Abstract submission : March 31, 2005
Registration : April 30, 2005
Hotel reservation : May 15, 2005
Payment (Registration fee + hotel deposit) : May 15, 2005

Scientific rationale:

During the last years, stars showing the B[e] phenomenon have always been treated as an undesirable branch of astrophysics and were always only side-products on conferences dealing with stars and stellar evolution. In fact, the last real conference on B[e] stars took place 7 years ago in Paris although the major problem, i.e. the question of which mechanism causes the B[e] phenomenon in stars that are in such a varity of evolutionary phases, is still far from being solved.

Stars with the B[e] phenomenon are found in almost every evolutionary phase. There are Herbig Ae/B[e] stars, B[e] supergiants, compact planetary nebulae, symbiotic objects, and a huge number of yet unclassified objects showing the B[e] phenomenon. Even these unclassified stars have recently been subgrouped, one subgroup being stars with warm dust. Inspecting this list it is clear, that the B[e] phenomenon is not restricted to stars of special initial condition (like e.g. initial mass) which makes it difficult to find a general mechanism for the phenomenon.

The purpose of this workshop is to gather experts from theory dealing with stellar evolution, stellar atmospheres, stellar winds, mass loss and outflowing disks, as well as from the observational side covering all wavelength bands to present and discuss the latest progresses observationally and theoretically in the field of B[e] stars.

Theoretical progress has mainly been made in the calculation of stellar evolution models including rotation and magnetic fields, and in first steps of including the effect of non-sphericity in stellar atmosphere models. In the observational part, the most important results in B[e] star research have been found from recent space missions like ISO, IUE and HST. In addition, high-resolution observations in different wavelength regions together with interferometric and polarimetric observations revealed newest insight into the geometry and chemical composition of the circumstellar matter.

We especially want to focus on the following questions :
– What causes the B[e] phenomenon?
– Does every B (and O?) star undergo a B[e] phase during its evolution?
– Which roles might play rotation, magnetic fields and especially binarity?
– What is the evolutionary connection of B[e] supergiants with other post-main sequence massive stars, especially with LBVs?
– What is the evolutionary status of the so-called "unclassified" B[e] stars?
– Is there any connection between the classical Be stars and B[e] stars?

Scientific organizing committee:

Francisco de Araujo, Brazil (araujo@on.br), Vera Arkhipova, Russia (vera@sai.msu.ru), Jon Bjorkman, USA (jbjorkman@mac.com), Karen Bjorkman, USA (karen@astro.utoledo.edu), Roberta Humphreys, USA (roberta@umn.edu), Michaela Kraus, The Netherlands (M.Kraus@phys.uu.nl) (chair), Georges Meynet, Switzerland (Georges.Meynet@obs.unige.ch), Anatoly Mirochnichenko, USA/Russia (anatoly@physics.utoledo.edu) (co-chair), Antonella Nota, USA (nota@stsci.edu), Philippe Stee, France (Philippe.Stee@obs-azur.fr).

IAU Symposium No.230
Dublin, Ireland
15–19 August 2005

At its meeting in Mexico City on 25 May 2004, the Executive Committee of the International Astronomical Union accepted the proposal for an IAU Symposium on "Populations of High-Energy Sources in Galaxies", to be held 15-19 August 2005 in Dublin, Ireland. This will be IAU Symposium No. 230. The venue will be Dublin Castle, in the centre of town.

With currently operational high-energy satellite observatories the potential for conducting detailed

studies of individual sources of high-energy radiation in other galaxies as well as in our own Milky Way has greatly increased.

Primary objectives

* Overview of key source categories in our Galaxy (X-ray and gamma-ray, the latter notably referring to INTEGRAL results)
Review of the results on individual high-energy sources in galaxies that have been obtained with Chandra and XMM-Newton
Derivation of global descriptions of high-energy source populations in galaxies
Assessment of the evolutionary status of stellar populations, derived from the X-ray investigations
Discussion of the high-redshift context of the source populations

Information

http://www.dunsink.dias.ie/IAUS230/index.html

Scientific Organizing Committee

E.J.A. Meurs (Ireland, Chair), G. Fabbiano (USA, Co-Chair), L. Bassani (Italy), B. McBreen (Ireland), H.-Y. Chu (USA), C. Done (UK), G. Hasinger (Germany), G. Koenigsberger (Mexico), K. Koyama (Japan), V. Lipunov (Russia), M.Mas-Hesse (Spain), Th. Montmerle (France), G. Romero (Argentina), Z. Wang (China).

Anticipated time timetable

October 2004 : 1st Announcement
15 December 2004 : deadline for pre-registration
January 2005 : 2nd Announcement
April 2005 : Final Announcement
1 June 2005 : Registration Deadline
15 August 2005 : Symposium programme starts

The purpose of the pre-registration is to gauge the interest in this Symposium, so as to assist SOC and LOC with their organization. The 2nd Announcement will contain the call for registration, information about hotel reservations, abstract submission, posters, proceedings, IAU travel grants, invited speakers and sponsorship.

With best regards,

Evert Meurs and Pepi Fabbiano (SOC Co-Chairs)
Brian McBreen (LOC Chair)

Books

New Astronomy Book: The Formation of Stars
Steven W. Stahler & Francesco Palla

Wiley-VCH announces the publication of The Formation of Stars, by Steven W. Stahler and Francesco Palla. This book is a comprehensive treatment of star formation, one of the most active fields of modern astronomy. The reader is guided through the subject in a logically compelling manner. Starting from a general description of stars and interstellar clouds, the authors delineate the earliest phases of stellar evolution. They discuss formation activity not only in the Milky Way, but also in other galaxies,

both now and in the remote past. Theory and observation are thoroughly integrated, with the aid of numerous figures and images. In summary, this book is an invaluable resource, both as a text for physics and astronomy graduate students, and as a reference for professional scientists.

Steven Stahler is a research astrophysicist at U. of California, Berkeley, USA.
Francesco Palla is a senior astronomer at the INAF-Osservatorio Astrofisico di Arcetri, in Florence, Italy.

From the Table of Contents:

Part I (4 chapters): Star Formation in our Galaxy
Part II (4 chapters): Physical Processes in Molecular Clouds
Part III (4 chapters): From Clouds to Stars
Part IV (3 chapters): Environmental Impact of Young Stars
Part V (3 chapters): Pre-Main-Sequence Stars
Part VI (2 chapters): A Universe of Stars

Publication date: November 2004; softcover
Approximately 850 pages with 400 figures, 13 in color
Price: approx. 68 euros/ 90 USD
ISBN 3-527-40559-3
Available now in Europe. Copies will arrive in US, Asia, etc in January.

To pre-order (from any country), use Amazon.com
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Jobs

Tenure-Track Positions
Utrecht University, The Netherlands

Two tenure-track positions (assistent professor level) at the Astronomical Institute at Utrecht University, The Netherlands.

The Astronomical Institute of Utrecht University is expanding.

At the moment we have two tenure-track job openings at assistent professor (UD)level: see AAS job register 21316 at www.aas.org. One of these is for a high energy (or sub-mm/IR) astrophysicist, to strengthen our ties with SRON Space Research Laboratory nextdoor. The other one is for a young and enthousiastic "observationally oriented" astrophysicist in the field of stellar or extragalactic astronomy. We are part of the largest University and the largest department of physics in Holland with a steady influx of students, many of excellent quality.

Information: www.astro.uu.nl/siu/vacancies.html or lamers@astro.uu.nl