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Accepted Papers

The 3D Morphology of VY Canis Majoris. I The Kinematics of the Ejecta

Roberta M. Humphreys, L. Andrew Helton, Terry J. Jones

University of Minnesota

Images of the complex circumstellar nebula associated with the famous red supergiant VY CMa show evidence for multiple and asymmetric mass loss events over the past 1000 yrs. Doppler velocities of the arcs and knots in the ejecta showed that they are not only spatially distinct but also kinematically separate from the surrounding diffuse material. In this paper we describe second epoch HST/WFPC2 images to measure the transverse motions which when combined with the radial motions provide a complete picture of the kinematics of the ejecta including the total space motions and directions of the outflows. Our results show that the arcs and clumps of knots are moving at different velocities, in different directions, and at different angles relative to the plane of the sky and to the star, confirming their origin from eruptions at different times and from physically separate regions on the star. We conclude that the morphology and kinematics of the arcs and knots are consistent with a history of mass ejections not aligned with any presumed axis of symmetry. The arcs and clumps represent relatively massive outflows and ejections of gas very likely associated with large – scale convective activity and magnetic fields.

Reference: Astronomical Journal

Preprints from: roberta@umn.edu

The 3D Morphology of VY Canis Majoris II: Polarimetry and the Line-of-Sight Distribution of the Ejecta

Terry Jay Jones, Roberta M. Humphreys, and L. Andrew Helton (1)
and Changfeng Gui and Xiang Huang (2)

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We use imaging polarimetry taken with the HST/ACS/HRC to explore the three dimensional structure of the circumstellar dust distribution around the red supergiant VY Canis Majoris. The polarization vectors of the nebulosity surrounding VY CMa show a strong centro-symmetric pattern in all directions except directly East and range from 10% - 80% in fractional polarization. In regions that are optically thin, and therefore likely have only single scattering, we use the fractional polarization and photometric color to locate the physical position of the dust along the line-of-sight. Most of the individual arc-like features and clumps seen in the intensity image are also features in the fractioanl polarization map. These features must be distinct geometric objects. If they were just local density enhancements, the fractional polarization would not change so abruptly at the edge of the feature. The location of these features in the ejecta of VY CMa using polarimetry provides a determination of their 3D geometry independent of, but in close agreement with, the results from our study of their kinematics (Paper I).

Reference: Astronomical Journal

Preprints from: `roberta@umn.edu`

Central Stars of Planetary Nebulae in the Galactic Bulge

P.J.N. Hultzsch, J. Puls, R.H. Mendez, A.W.A. Pauldrach,
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Context: Optical high-resolution spectra of five central stars of planetary nebulae (CSPN) in the Galactic Bulge have been obtained with Keck/HIRES in order to derive their parameters. Since the distance of the objects is quite well known, such a method has the advantage that stellar luminosities and masses can in principle be determined without relying on theoretical relations between both quantities.

Aims: By alternatively combining the results of our spectroscopic investigation with evolutionary tracks, we obtain so-called spectroscopic distances, which can be compared with the known (average) distance of the Bulge-CSPN. This offers the possibility to test the validity of model atmospheres and present date post-AGB evolution.

Methods: We analyze optical H/He profiles of five Galactic Bulge CSPN (plus one comparison object) by means of profile fitting based on state of the art non-LTE modeling tools, to constrain their basic atmospheric parameters (Teff, log g, helium abundance and wind strength). Masses and other stellar radius dependent quantities are obtained from both the known distances and from evolutionary tracks, and the results from both approaches are compared.

Results: The major result of the present investigation is that the derived spectroscopic distances depend crucially on the applied reddening law. Assuming either standard reddening or values based on radio-Hbeta extinctions, we find a mean distance of 9.0 +/- 1.6 kpc and 12.2 +/- 2.1 kpc, respectively.

An "average extinction law" leads to a distance of 10.7 +/- 1.2 kpc, which is still considerably larger than the Galactic Center distance of 8 kpc. In all cases, however, we find a remarkable INTERNAL AGREEMENT of the individual spectroscopic distances of our sample objects, within +/- 10% to +/- 15% for the different reddening laws.

Conclusions: Due to the uncertain reddening correction, the analysis presented here cannot yet be regarded as a consistency check for our method, and a rigorous test of the CSPN evolution theory becomes only possible if this problem has been solved.

Reference: A&A, accepted; astro-ph/0702755

Comments: Though dealing with post-AGB objects, this paper might also be interesting for the "massive star community", since it investigates, among other topics, their line-driven winds and clumping.

On the web at: `http://www.usm.uni-muenchen.de/people/puls/papers/cspn.pdf`

Preprints from: `pjnh@usm.uni-muenchen.de`

An XMM-Newton view of the young open cluster NGC 6231 III. Optically faint X-ray sources

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We discuss the properties of the X-ray sources with faint optical counterparts in the very young open cluster NGC 6231. From their positions in the H-R diagram, we find that the bulk of these objects probably consists of low-mass pre-main sequence stars with masses in the range 0.3 to 3.0 $M_\odot$. The age distribution of these objects indicates that low-mass star formation in NGC 6231 started more than 10 Myr ago and culminated in a starburst-like event about 1 to 4 Myr ago when the bulk of the low-mass PMS stars as well as the massive cluster members formed. We find no evidence for a spatial age gradient that could point towards a sequential star formation process. Only a few X-ray sources have counterparts with a reddening exceeding the average value of the cluster or with infrared colours indicating the presence of a moderate near-IR excess. The X-ray spectra of the brightest PMS sources are best fitted by rather hard thermal plasma models and a significant fraction of these sources display flares in their light curve. The X-ray brightest flaring sources have decay times between 2 and 16 ks. The X-ray selected PMS stars in NGC 6231 have $\log L_{\rm X}/L_{\rm bol}$ values that increase strongly with decreasing bolometric luminosity and can reach a saturation level ($\log L_{\rm X}/L_{\rm bol} \sim -2.4$) for non-flaring sources and even more extreme values during flares.

Reference: Accepted by MNRAS

On the web at: `http://arxiv.org/abs/astro-ph/0703104`

Preprints from: `hsana@eso.org`

A New Numerical Method for Solving Radiation Driven Winds from Hot Stars

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We present a general method for solving the non–linear differential equation of monotonically increasing steady–state radiation driven winds. We graphically identify all the singular points before transforming the momentum equation to a system of differential equations with all the gradients explicitly give. This permits a topological classification of all singular points and to calculate the maximum and minimum mass–loss of the wind. We use our method to analyse for the first time the topology of the non–rotating frozen in ionisation m–CAK wind, with the inclusion of the finite disk correction factor and find up to 4 singular points, three of the x–type and one attractor–type. The only singular point (and solution passing through) that satisfies the boundary condition at the stellar surface is the standard m–CAK singular point.

Reference: Accepted for publication in Astronomische Nachrichten / Astronomical Notes

On the web at: `http://xxx.lanl.gov/abs/astro-ph/0703148`

Preprints from: `michel.cure@uv.cl`

Stellar and wind properties of massive stars in the central parsec of the Galaxy

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We study the stellar and wind properties of massive stars in the central cluster of the Galaxy. We use non-LTE atmosphere models including winds and line-blanketing to fit their H and K band spectra obtained with the 3D spectrograph SINFONI on the VLT. We derive the main stellar (Teff, L, abundances, ionizing flux) and wind (mass loss rate, terminal velocity) properties. They are found to be similar to other galactic massive stars. We show that a direct evolutionary link between Ofpe/WN9, WN8 and WN/C stars exists. Using individual SEDs for each massive star, we construct the total spectral energy distribution of the cluster and use it to compute photoionization models. We show that the nebular properties of the central HII region are well reproduced. We conclude that, contrary to previous claims, standard stellar evolution and atmosphere models are well suited to explain the properties of the central cluster. Our results indicate that massive stars in the central cluster do not have a peculiar evolution as could be expected from their proximity to the supermassive black hole SgrA*.

Reference: A&A acceoted

On the web at: `http://arxiv.org/abs/astro-ph/0703211`

Preprints from: `martins@mpe.mpg.de`

Fourier method in the determination of rotational velocities in OB stars

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We present a comprehensive study that applies the Fourier transform to a sample of O and early B-type stars (either dwarfs, giants, or supergiants) to determine their projected rotational velocities, compare with previous values obtained with other methods, and seek for evidence of extra broadening in the spectral lines The Fourier technique, extensively used in the study of cooler stars, has remained only marginally applied for the case of early-type stars. The comparison of vsini values obtained through the ft and fwhm methods shows that the fwhm technique must be used with care in the analysis of OB giants and supergiants, and when it is applied to ionHei lines. Contrarily, the ft method appears to be a powerful tool to derive reliable projected rotational velocities, and separate the effect of rotation from other broadening mechanisms present in these stars. The analysis of the sample of OB stars shows that while dwarfs and giants display a broad range of projected rotational velocities, from less than 30 up to 450 $\mathrm{km\,s^{-1}}$, supergiants have in general values close to or below 100 $\mathrm{km\,s^{-1}}$. The analysis has also definitely shown that while the effect of extra broadening is negligible in OB dwarfs, it is clearly present in supergiants. When examining the behavior of the projected rotational velocities with the stellar parameters and across the HR diagram, we conclude, in agreement with previous researchers, that the rotational velocity should decrease when the stars evolve. On the contrary, macroturbulence may be constant, resulting therefore in an increasing importance as compared to rotation when the stars evolve.

Reference: A&A

On the web at: `http://xxx.lanl.gov/abs/astro-ph/0703216`

Preprints from: `sergio.simon-diaz@obspm.fr`

VLT/NACO near-infrared imaging and spectroscopy of N159-5 in the LMC HII complex N159

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We present high resolution near-infrared imaging of the compact HII region N159-5 and its immediate environment in the giant star forming region N159 in the LMC. N159-5 was observed at high spatial resolution $\sim 0''.11$–$0''.25$ in the K-band using the ESO Very Large Telescope UT4 (VLT), equipped with the NAOS adaptive optics system. Our data reveal that N159-5 has a complex morphology formed mainly by two wings and probably a single central bright star, embedded in diffuse emission of $\sim 4''.5$ diameter. A remarkable embedded tight cluster of approximatively the same size, containing at least 38 faint stars coinciding with N159-5, is also detected. Such clusters can be found in galactic HII regions like the star forming regions SH2 269 or M42. At the location of the radio peak, especially in

the bright western wing, this cluster is rich in stars. Spectroscopic observations reveal that the diffuse region is constituted mainly of dust continuum, and that the bright star # 2-55 could be of type O8 V. A comparison with the radio observation flux of N159-5 published in the literature seems to show that the bright star # 2-55 is not the only ionization source of N159-5. Towards N159-5 molecular H_2 emission is detected. A model of the region is proposed.

Reference: A&A

Preprints from: gerard.testor@obspm.fr

Detection of variable Si II, Mn II and Fe II emission lines in the magnetic Bp star a Centauri

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The nature of non-variable high-excitation emission lines detected in the optical spectra of normal late-B type and chemically peculiar HgMn and PGa stars is still poorly understood.

To better understand the origin of the weak emission lines in B type stars it is especially important to investigate the spectra of a variety of stars to search for correlations between the emergence of these lines and fundamental stellar parameters.

We have acquired high resolution UVES spectra for the sharp-lined magnetic helium-variable star a Cen over the rotation period of 8.82 d to search for the presence of weak emission lines.

For the first time we present observational evidence for the appearance of variable high-excitation Si II, Mn II and Fe II emission lines in a magnetic Bp star. Si II emissions are the strongest at the phase corresponding to the maximum strength of He I lines. Mn II and Fe II emissions vary in antiphase to the He I lines. A correlation is found between the probable location of Mn and Fe surface spots and the strength of the emission lines. On the basis of the currently available data it seems possible that the same kind of selective excitation process is working in the atmospheres of objects within a broad parameter space which could be defined by age, effective temperature, chemical composition, rotational velocity, and magnetic field. Neutral iron lines previously reported to appear broad and shallow at certain phases are not detected in our spectra, although two of them are identified as He I forbidden lines, showing maximum strength at the phase of the passage of the He rich region across the visible disk.

Reference: Accepted for publication in A&A

On the web at: http://arxiv.org/abs/astro-ph/0703229

Preprints from: shubrig@eso.org

A Clumping Independent Diagnostic of Stellar Mass-loss Rates: Rapid Clump Destruction in Adiabatic Colliding Winds

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Clumping in hot star winds can significantly affect estimates of mass-loss rates, the inferred evolution of the star and the environmental impact of the wind. A hydrodynamical simulation of a colliding winds binary (CWB) with clumpy winds reveals that the clumps are rapidly destroyed after passing through the confining shocks of the wind-wind collision region (WCR) for reasonable parameters of the clumps if the flow in the WCR is adiabatic. Despite large density and temperature fluctuations in the post-shock gas, the overall effect of the interaction is to smooth the existing structure in the winds. Averaged over the entire interaction region, the resulting X-ray emission is very similar to that from the collision of smooth winds. The insensitivity of the X-ray emission to clumping suggests it is an excellent diagnostic of the stellar mass-loss rates in wide CWBs, and may prove to be a useful addition to existing techniques for deriving mass-loss rates, many of which are extremely sensitive to clumping. Clumpy winds also have implications for a variety of phenomena at the WCR: particle acceleration may occur throughout the WCR due to supersonic MHD turbulence, re-acceleration at multiple shocks, and re-connection; a statistical description of the properties of the WCR may be required for studies of non-equilibrium ionization and the rate of electron heating; and the physical mixing of the two winds will be enhanced, as seems necessary to trigger dust formation.

Reference: Accepted by ApJL

On the web at: `astro-ph/0703617`

Preprints from: `jmp@ast.leeds.ac.uk`

Testing the predicted mass-loss bi-stability jump at radio wavelengths

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Massive stars play a dominant role in the Universe, but one of the main drivers for their evolution, their mass loss, remains poorly understood. In this study, we test the theoretically predicted mass-loss behaviour as a function of stellar effective temperature across the so-called 'bi-stability' jump. We

observe OB supergiants in the spectral range O8-B3 at radio wavelengths to measure their thermal radio flux densities, and complement these measurements with data from the literature. We derive the radio mass-loss rates and wind efficiencies, and compare our results with Halpha mass-loss rates and predictions based on radiation-driven wind models. The wind efficiency shows the possible presence of a local maximum around an effective temperature of 21 000 K - in qualitative agreement with predictions. Furthermore, we find that the absolute values of the radio mass-loss rates show good agreement with empirical Halpha rates derived assuming homogeneous winds - for the spectral range under consideration. However, the empirical mass-loss rates are larger (by a factor of a few) than the predicted rates from radiation-driven wind theory for objects above the bi-stability jump (BSJ) temperature, whilst they are smaller (by a factor of a few) for stars below the BSJ temperature. The reason for these discrepancies remains as yet unresolved. A new wind momenta-luminosity relation (WLR) for O8-B0 stars has been derived using the radio observations. The validity of the WLR as a function of the fitting parameter related to the force multiplier alpha(eff) (Kudritzki & Puls 2000) is discussed. Our most interesting finding is that the qualitative behaviour of the empirical wind efficiencies with effective temperature is in line with the predicted behaviour, and this presents the first hint of empirical evidence for the predicted mass-loss bi-stability jump. However, a larger sample of stars around the BSJ needs to be observed to confirm this finding.

Reference: The paper is recommended for publication in A&A (astro-ph/0703577)

On the web at: `www.iar.unlp.edu.ar/garra/garra-pb.html`

Preprints from: `pbenaglia@fcaglp.unlp.edu.ar`

Modelling the clumping-induced polarimetric variability of hot star winds

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Clumping in the winds of massive stars may significantly reduce empirical mass-loss rates, and which in turn may have a large impact on our understanding of massive star evolution. Here, we investigate wind-clumping through the linear polarization induced by light scattering off the clumps. Through the use of an analytic wind clumping model, we predict the time evolution of the linear polarimetry over a large parameter space. We concentrate on the Luminous Blue Variables, which display the greatest amount of polarimetric variability and for which we recently conducted a spectropolarimetric survey. Our model results indicate that the observed level of polarimetric variability can be reproduced for two regimes of parameter space: one of a small number of massive, optically-thick clumps; and one of a very large number of low-mass clumps. Although a systematic time-resolved monitoring campaign is required to distinguish between the two scenarios, we currently favour the latter, given the short timescale of the observed polarization variability. As the polarization is predicted to scale linearly with mass-loss rate, we anticipate that all hot stars with very large mass-loss rates should display

polarimetric variability. This is consistent with recent findings that intrinsic polarization is more common in stars with strong H*alpha* emission.

Reference: Accepted for publication in A&A

On the web at: `http://www.cis.rit.edu/~bxdpci/7193accepted.pdf`

Preprints from: `davies@cis.rit.edu`

Constraining GRB progenitor models by probing Wolf-Rayet wind geometries in the Large Magellanic Cloud

Jorick S. Vink

Armagh Observatory

The favoured progenitors of long-duration gamma-ray bursts (GRBs) are rapidly rotating Wolf-Rayet (WR) stars. However, most Galactic WR stars are slow rotators, as stellar winds are thought to remove angular momentum. This poses a serious challenge to the collapsar model. Recent observations indicate that GRBs occur predominately in low metallicity (Z) environments, which may resolve the problem: lower Z leads to less mass loss, which may inhibit angular momentum removal, allowing WR stars to remain rotating rapidly until collapse. We wish to determine whether low Z WR stars rotate on average more rapidly than Galactic WR stars. We perform a Very Large Telescope (VLT) linear spectropolarimetry survey of WR stars in the low Z environment of the Large Magellanic Cloud (LMC) and compare our results with the Galactic sample of Harries et al. (1998). We find that only 2 out of 13 (i.e. 15%) of LMC WR stars show line polarization effects, compared to a similarly low fraction of ~15-20% for Galactic WR stars. The low incidence of line polarization effects in LMC WR stars suggests that the threshold metallicity where significant differences in WR rotational properties occur is below that of the LMC (Z ~0.5 Zsun), possibly constraining GRB progenitor channels to this upper metallicity.

Reference: A&A, astro-ph/0704.2690

On the web at: `http://www.arm.ac.uk/~jsv/`

Preprints from: `jsv@arm.ac.uk`

Luminous blue variables as the progenitors of supernovae with quasi-periodic radio modulations

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The interaction between supernova ejecta and circumstellar matter, arising from previous episodes of mass loss, provides us with a means of constraining the progenitors of supernovae. Radio observations of a number of supernovae show quasi-periodic deviations from a strict power-law decline at late times. Although several possibilities have been put forward to explain these modulations, no single

explanation has proven to be entirely satisfactory. Here we suggest that Luminous blue variables undergoing S-Doradus type variations give rise to enhanced phases of mass loss that are imprinted on the immediate environment of the exploding star as a series of density enhancements. The variations in mass loss arise from changes in the ionization balance of Fe, the dominant ion that drives the wind. With this idea, we find that both the recurrence timescale of the variability and the amplitude of the modulations are in line with the observations. Our scenario thus provides a natural, single-star explanation for the observed behaviour that is, in fact, expected on theoretical grounds.

Reference: 2006, A&A 460L, 5

Preprints from: jsv@arm.ac.uk

Proceedings

The Galactic O Star Catalog V.2.0

Alfredo Sota (1), Jesús Maíz Apellíniz (2), Nolan R. Walborn (1), and Raquel Y. Shida (3)

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The Galactic O star catalog (GOS) is an ambitious project to provide as much information regarding these types of objects as possible. The first version of the catalog (GOS v1) included data for 378 stars with precise spectral classification. It was intended to be complete up to $V < 8$, but also included many stars fainter than that limit. In this new version, we include a second list with more than 700 stars that have sometimes been classified as O stars. The catalog includes cross-references to other catalogs, spectral classification (various references for each star on the second list), coordinates (obtained in most cases from Tycho-2 data, but some from 2MASS and USNO B1), astrometric distances for some of the nearer stars, Optical and NIR photometry (Tycho-2, Johnson, Stromgren, Cousin and 2MASS), group membership, runaway character, and multiplicity information.

Reference: "Massive Stars: Fundamental Parameters and Circumstellar Interactions" Carilo, Argentina December 11-14, 2006

On the web at: http://arxiv.org/abs/astro-ph/0703005

Preprints from: asota@stsci.edu

Jobs

Postdoctoral Position On Massive Stars

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Applications are invited for a postdoctoral position at Laboratoire d'Astrophysique de Marseille. The appointee will work with Dr. Jean-Claude Bouret and is expected to participate actively in our on-going research on the atmospheres and winds of early-type massive stars. The research project aims at a better understanding of the role of rotation and magnetic fields on the dynamics of the winds of massive stars. External members associated to this project include Thierry Lanz (University of Maryland) and John Hillier (University of Pittsburgh). To take advantage of the collaborative aspects of this project, the appointee will be encouraged to spend a few months at these institutions. This program is funded by the French National Science Agency (ANR) and hosted by Groupe de Recherche en Astronomie et Astrophysique du Languedoc (GRAAL). Our main objective is to achieve a better understanding and treatment of mass loss in the latest generation of model stellar atmospheres, for stars in the upper HR diagram (for more details, see http://www.graal.univ-montp2.fr/perso/josselin/MaSiLU.html).

The successful candidate should have experience in the area of radiative transfer, spectrum synthesis and stellar atmosphere modelling. The net salary is about 1700 per month, national health insurance and pension plan are provided. Access to a 8-core shared memory computer server and travel funds will be available.

The appointment is for two years, and should start no later than October 2007. To apply, please send a resume, bibliography, statement of research and three letters of reference to the above address, before May 15th, 2007. Additional informations can be requested from Jean-Claude Bouret (Jean-Claude.Bouret@oamp.fr).

Weblink: `http://www.graal.univ-montp2.fr/perso/josselin/MaSiLU.html`

Email contact: `jean-claude.bouret@oamp.fr`

Closing date: May 15th, 2007