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Atmospheric NLTE-Models for the Spectroscopic Analysis of Blue Stars with Winds.
III. X-ray emission from wind-embedded shocks

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Context. X-rays/EUV radiation emitted from wind-embedded shocks in hot, massive stars can affect the ionization balance in their outer atmospheres, and can be the mechanism responsible for the production of highly ionized atomic species detected in stellar wind UV spectra.

Aims. To allow for these processes in the context of spectral analysis, we have implemented the emission from wind-embedded shocks and related physics into our unified, NLTE model atmosphere/spectrum synthesis code FASTWIND.

Methods. The shock structure and corresponding emission is calculated as a function of user-supplied parameters (volume filling factor, radial stratification of shock strength, and radial onset of emission). We account for a temperature and density stratification inside the post-shock cooling zones, calculated for radiative and adiabatic cooling in the inner and outer wind, respectively. The high-energy absorption of the cool wind is considered by adding important K-shell opacities, and corresponding Auger ionization rates have been included into the NLTE network. To test our implementation and to check the resulting effects, we calculated a comprehensive model grid with a variety of X-ray emission parameters.

Results. We tested and verified our implementation carefully against corresponding results from various alternative model atmosphere codes, and studied the effects from shock emission for important ions from He, C, N, O, Si, and P. Surprisingly dielectronic recombination turned out to play an essential role for the

ionization balance of OIV/OV in stars (particularly dwarfs) with Teff approx. 45,000 K. Finally, we investigated the frequency dependence and radial behavior of the mass absorption coefficient, kappa_nu(r), important in the context of X-ray line formation in massive star winds.

Conclusions. In almost all considered cases, direct ionization is of major influence (because of the enhanced EUV radiation field), and Auger ionization significantly affects only NVI and OVI. The approximation of a radially constant kappa_nu is justified for r > 1.2 Rstar and lambda < 18 A, and also for many models at longer wavelengths. To estimate the actual value of this quantity, however, the HeII opacities need to be calculated from detailed NLTE modeling, at least for wavelengths longer than 18 to 20 A, and information on the individual CNO abundances has to be present.

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Two bi-stability jumps in theoretical wind models for massive stars and the implications for luminous blue variable supernovae

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Luminous Blue Variables have been suggested to be the direct progenitors of supernova types IIb and IIn, with enhanced mass loss prior to explosion. However, the mechanism of this mass loss is not yet known. Here, we investigate the qualitative behaviour of theoretical stellar wind mass-loss as a function of Teff across two bi-stability jumps in blue supergiant regime and also in proximity to the Eddington limit, relevant for LBVs. To investigate the physical ingredients that play a role in the radiative acceleration we calculate blue supergiant wind models with the CMFGEN non-LTE model atmosphere code over an effective temperature range between 30 000 and 8 800 K. Although our aim is not to provide new mass-loss rates for BA supergiants, we study and confirm the existence of two bi-stability jumps in mass-loss rates predicted by Vink, de Koter, & Lamers (1999). However, they are found to occur at somewhat lower Teff (20 000 and 9 000 K, respectively) than found previously, which would imply that stars may evolve towards lower Teff before strong mass-loss is induced by the bi-stability jumps. When the combined effects of the second bi-stability jump and the proximity to Eddington limit are accounted for, we find a dramatic increase in the mass-loss rate by up to a factor of 30. Further investigation of both bi-stability jumps is expected to lead to a better understanding of discrepancies between empirical modelling and theoretical mass-loss rates reported in the literature, and to provide key inputs for the evolution of both normal AB supergiants and LBVs, as well as their subsequent supernova type II explosions.

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Measuring the stellar wind parameters in IGR J17544-2619 and Vela X-1 constrains the accretion physics in Supergiant Fast X-ray Transient and classical Supergiant X-ray Binaries

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Classical Supergiant X-ray Binaries (SGXBs) and Supergiant Fast X-ray Transients (SFXTs) are two types of High-mass X-ray Binaries (HMXBs) that present similar donors but, at the same time, show very different behavior in the X-rays. The reason for this dichotomy of wind-fed HMXBs is still a matter of debate. Among the several explanations that have been proposed, some of them invoke specific stellar wind properties of the donor stars. Only dedicated empiric analysis of the donors' stellar wind can provide the required information to accomplish an adequate test of these theories. However, such analyses are scarce. To close this gap, we perform a comparative analysis of the optical companion in two important systems: IGR J17544-2619 (SFXT) and Vela X-1 (SGXB). We analyse the spectra of each star in detail and derive their stellar and wind properties. We compare the wind parameters, giving us an excellent chance of recognizing key differences between donor winds in SFXTs and SGXBs. We find that the stellar parameters derived from the analysis generally agree well with the spectral types of the two donors: O9I (IGR J17544-2619) and B0.5Iae (Vela X-1). An important difference between the stellar winds of the two stars is their terminal velocities v_inf=1500km/s in IGR J17544-2619 and v_inf=700km/s in Vela~X-1, which has important consequences on the X-ray luminosity of these sources. Their specific combination of wind speed and pulsar spin favours an accretion regime with a persistently high luminosity in Vela X-1, while it favours an inhibiting accretion mechanism in IGR~J17544-2619. Our study demonstrates that the wind relative velocity is critical in the determination of the class of HMXBs hosting a supergiant donor, given that it may shift the accretion mechanism from direct accretion to propeller regimes when combined with other parameters.

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Searching for a magnetic field in Wolf-Rayet stars using FORS2 spectropolarimetry

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To investigate if magnetic fields are present in Wolf-Rayet stars, we selected a few stars in the Galaxy and one in the Large Magellanic Cloud (LMC). We acquired low-resolution spectropolarimetric observations with the ESO FORS2 instrument during two different observing runs. During the first run in visitor mode, we observed the LMC Wolf-Rayet star BAT99 7 and the stars WR6, WR7, WR18, and WR23 in our Galaxy. The second run in service mode was focused on monitoring the star WR6. Linear polarization was recorded immediately after the observations of circular polarization. During our visitor observing run, the magnetic field for the cyclically variable star WR6 was measured at a significance level of 3.3sigma (= 258+-78G). Among the other targets, the highest value for the longitudinal magnetic field, = 327+-141G, was measured in the LMC star BAT99 7. Spectropolarimetric monitoring of the star WR6 revealed a sinusoidal nature of the variations with the known rotation period of 3.77d, significantly adding to the confidence in the detection. The presence of the rotation-modulated magnetic variability is also indicated in our frequency periodogram. The reported field magnitude suffers from significant systematic uncertainties at the factor 2 level, in addition to the quoted statistical uncertainties, owing to the theoretical approach used to characterize it. Linear polarization measurements showed no line effect in the stars, apart from WR6. BAT99 7, WR7, and WR,23 do not show variability of the linear polarization over two nights.

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Surface abundances of OC supergiants

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Some O and B stars show unusually strong or weak lines of carbon and/or nitrogen. These objects are classified as OBN or OBC stars. It has recently been shown that nitrogen enrichment and carbon depletion are the most likely explanations for the existence of the ON class. We investigate OC stars (all being supergiants) to check that surface abundances are responsible for the observed anomalous line strengths. We perform a spectroscopic analysis of three OC supergiants using atmosphere models. A

fourth star was previously studied by us. Our sample thus comprises all OC stars known to date in the Galaxy. We determine the stellar parameters and He, C, N, and O surface abundances. We show that all stars have effective temperatures and surface gravities fully consistent with morphologically normal O supergiants. However, OC stars show little, if any, nitrogen enrichment and carbon surface abundances consistent with the initial composition. OC supergiants are thus barely chemically evolved, unlike morphologically normal O supergiants.

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A test for the theory of colliding winds: the periastron passage of 9 Sagittarii
I. X-ray and optical spectroscopy

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The long-period, highly eccentric O-star binary 9 Sgr, known for its non-thermal radio emission and its relatively bright X-ray emission, went through its periastron in 2013. Such an event can be used to observationally test the predictions of the theory of colliding stellar winds over a broad range of wavelengths. We have conducted a multi-wavelength monitoring campaign of 9 Sgr around the 2013 periastron. In this paper, we focus on X-ray observations and optical spectroscopy. The optical spectra allow us to revisit the orbital solution of 9 Sgr and to refine its orbital period to 9.1 years. The X-ray flux is maximum at periastron over all energy bands, but with clear differences as a function of energy. The largest variations are observed at energies above 2 keV, whilst the spectrum in the soft band (0.5 - 1.0 keV) remains mostly unchanged indicating that it arises far from the collision region, in the inner winds of the individual components. The level of the hard emission at periastron clearly deviates from the 1/r relation expected for an adiabatic wind interaction zone, whilst this relation seems to hold at the other phases covered by our observations. The spectra taken at phase 0.946 reveal a clear Fe xxv line at 6.7 keV, but no such line is detected at periastron although a simple model predicts a strong line that should be easily visible in the data. The peculiarities of the X-ray spectrum of 9 Sgr could reflect the impact of radiative inhibition as well as a phase-dependent efficiency of particle acceleration on the shock properties.

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Direct Detection of Lyman Continuum Escape from Local Starburst Galaxies with the Cosmic Origins Spectrograph

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We report on the detection of Lyman continuum radiation in two nearby starburst galaxies. Tol 0440-381, Tol 1247-232 and Mrk 54 were observed with the Cosmic Origins Spectrograph onboard the Hubble Space Telescopes. The three galaxies have radial velocities of ~13,000 km/s, permitting a ~35 A window on the restframe Lyman continuum shortward of the Milky Way Lyman edge at 912 A. The chosen instrument configuration using the G140L grating covers the spectral range from 912 to 2,000 A. We developed a dedicated background subtraction method to account for temporal and spatial background variations of the detector, which is crucial at the low flux levels around 912 A. This modified pipeline allowed us to significantly improve the statistical and systematic detector noise and will be made available to the community. We detect Lyman continuum in all three galaxies. However, we conservatively interpret the emission in Tol 0440-381 as an upper limit due to possible contamination by geocoronal Lyman series lines. We determined the current star-formation properties from the far-ultraviolet continuum and spectral lines and used synthesis models to predict the Lyman continuum radiation emitted by the current population of hot stars. We discuss the various model uncertainties such as, among others, atmospheres and evolution models. Lyman continuum escape fractions were derived from a comparison between the observed and predicted Lyman continuum fluxes. Tol 1247-232, Mrk 54 and Tol 0440-381 have absolute escape fractions of (4.5 +/- 1.2)%, (2.5 +/- 0.72)% and <(7.1 +/- 1.1)%, respectively.

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Searching for Cool Dust in the Mid-to-far Infrared: The Mass-loss Histories of the Hypergiants μ Cep, VY CMa, IRC+10420, and ρ Cas

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We present mid- and far-IR imaging of four famous hypergiant stars: the red supergiants μ Cep and VY CMa, and the warm hypergiants IRC +10420 and ρ Cas. Our 11–37 μm SOFIA/FORCAST imaging probes cool dust not detected in visual and near-IR imaging studies. Adaptive optics 8–12 μm imaging of μ Cep and IRC +10420 with MMT/MIRAC reveals extended envelopes that are the likely sources of these stars' strong silicate emission features. We find μ Cep's mass-loss rate to have declined by about a factor of five over a 13,000 year history, ranging from 5 × 10-6 down to ∼1× 10-6 M⊙ yr-1. The morphology of VY CMa indicates a cooler dust component coincident with the highly asymmetric

reflection nebulae seen in the visual and near-IR. The lack of cold dust at greater distances around VY CMa indicates that its mass-loss history is limited to the last ∼1200 years, with an average rate of 6 × 10-4 M⊙ yr-1. We find two distinct periods in the mass-loss history of IRC +10420 with a high rate of 2 × 10-3 M⊙ yr-1 until approximately 2000 years ago, followed by an order of magnitude decrease in the recent past. We interpret this change as evidence of its evolution beyond the RSG stage. Our new infrared photometry of ρ Cas is consistent with emission from the expanding dust shell ejected in its 1946 eruption, with no evidence of newer dust formation from its more recent events.

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Star-formation history and X-ray binary populations: the case of the Large Magellanic Cloud

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In the present work we investigate the link between high-mass X-ray binaries (HMXBs) and star formation in the Large Magellanic Cloud (LMC), our nearest star-forming galaxy. Using optical photometric data, we identify the most likely counterpart of 44 X-ray sources. Among the 40 HMXBs classified in this work, we find 33 Be/X-ray binaries, and 4 supergiant XRBs. Using this census and the published spatially resolved star-formation history map of the LMC, we find that the HMXBs (and as expected the X-ray pulsars) are present in regions with star-formation bursts ~6-25 Myr ago, in contrast to the Small Magellanic Cloud (SMC), for which this population peaks at later ages (~25-60 Myr ago). We also estimate the HMXB production rate to be equal to 1 system per ~(23.0+4.4-4.1) x 10^{-3} Mo/yr or 1 system per ~143 Mo of stars formed during the associated star-formation episode. Therefore, the formation efficiency of HMXBs in the LMC is ~17 times lower than that in the SMC. We attribute this difference primarily in the different ages and metallicity of the HMXB populations in the two galaxies. We also set limits on the kicks imparted on the neutron star during the supernova explosion. We find that the time elapsed since the supernova kick is ~3 times shorter in the LMC than the SMC. This in combination with the average offsets of the HMXBs from their nearest star clusters results in ~4 times faster transverse velocities for HMXBs in the LMC than in the SMC.

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A Spectroscopic Survey of Massive Stars in M31 and M33

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We describe our spectroscopic follow-up to the Local Group Galaxy Survey (LGGS) photometry of M31 and M33. We have obtained new spectroscopy of 1895 stars, allowing us to classify 1496 of them for the first time. Our study has identified many foreground stars, and established membership for hundreds of early- and mid-type supergiants. We have also found 9 new candidate Luminous Blue Variables and a previously unrecognized Wolf-Rayet star. We republish the LGGS M31 and M33 catalogs with improved coordinates and including spectroscopy from the literature and our new results. The spectroscopy in this paper is responsible for the vast majority of the stellar classifications in these two nearby spiral neighbors. The most luminous (and hence massive) of the stars in our sample are early-type B supergiants, as expected; the more massive O stars will be fainter visually, and thus mostly remain unobserved so far. The majority of the unevolved stars in our sample are in the 20-40Mo range.

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Comments: Full copies of revised LGGS catalogs may be downloaded from http://www.lowell.edu/users/massey/table5full.txt and http://wwwllowell.edu/users/massey/table6full.txt

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Wolf-Rayet stars in the Small Magellanic Cloud: II. Analysis of the binaries

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Massive WR stars are evolved massive stars characterized by strong mass-loss. Hypothetically, they can form either as single stars or as mass donors in close binaries. About 40% of the known WR stars are confirmed binaries, raising the question as to the impact of binarity on the WR population. By performing a spectral analysis of all multiple WR systems in the SMC, we obtain the full set of stellar parameters for each individual component. Mass-luminosity relations are tested, and the importance of the binary evolution channel is assessed. The spectral analysis is performed with the PoWR model atmosphere code by superimposing model spectra that correspond to each component. Evolutionary channels are constrained using the BPASS evolution tool. Significant Hydrogen mass fractions (0.1 - 0.4) are detected in all WN components. A comparison with mass-luminosity relations and evolutionary tracks implies that the majority of the WR stars in our sample are not chemically homogeneous. The WR component in the binary AB 6 is found to be very luminous (Log L ~ 6.3 [Lsun]) given its orbital mass (~10 Msun), presumably because of observational contamination by a third component. Evolutionary paths derived for

our objects suggest that Roche lobe overflow had occurred in most systems, affecting their evolution. However, the implied initial masses are large enough for the primaries to have entered the WR phase, regardless of binary interaction. Together with the results for the putative single SMC WR stars, our study suggests that the binary evolution channel does not dominate the formation of WR stars at SMC metallicity.

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The first spectropolarimetric monitoring of the peculiar O4Ief supergiant zeta Puppis

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The origin of the magnetic field in massive O-type stars is still under debate. To model the physical processes responsible for the generation of O star magnetic fields, it is important to understand whether correlations between the presence of a magnetic field and stellar evolutionary state, rotation velocity, kinematical status, and surface composition can be identified. The O4Ief supergiant zeta Pup is a fast rotator and a runaway star, which may be a product of a past binary interaction, possibly having had an encounter with the cluster Trumper 10 some 2Myr ago. The currently available observational material suggests that certain observed phenomena in this star may be related to the presence of a magnetic field. We acquired spectropolarimetric observations of zeta Pup with FORS2 mounted on the 8-m Antu telescope of the VLT to investigate if a magnetic field is indeed present in this star. We show that many spectral lines are highly variable and probably vary with the recently detected period of 1.78d. No magnetic field is detected in zeta Pup, as no magnetic field measurement has a significance level higher than 2.4sigma. Still, we studied the probability of a single sinusoidal explaining the variation of the longitudinal magnetic field measurements.

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The X-ray light curve of the massive colliding wind Wolf-Rayet + O binary WR21a

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Our dedicated XMM-Newton monitoring, as well as archival Chandra and Swift datasets, were used to examine the behaviour of the WN5h+O3V binary WR21a at high energies. For most of the orbit, the X-ray emission exhibits few variations. However, an increase in strength of the emission is seen before periastron, following a 1/D relative trend, where D is the separation between both components. This increase is rapidly followed by a decline due to strong absorption as the Wolf-Rayet (WR) comes in front. The fitted local absorption value appears to be coherent with a mass-loss rate of about 1$\times$10^{-5} M$_{\odot}$/yr for the WR component. However, absorption is not the only parameter affecting the X-ray emission at periastron as even the hard X-ray emission decreases, suggesting a possible collapse of the colliding wind region near to or onto the photosphere of the companion just before or at periastron. An eclipse may appear as another potential scenario, but it would be in apparent contradiction with several lines of evidence, notably the width of the dip in the X-ray light curve and the absence of variations in the UV light curve. Afterwards, the emission slowly recovers, with a strong hysteresis effect. The observed behaviour is compatible with predictions from general wind-wind collision models although the absorption increase is too shallow.

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Alpha Virginis: line-profile variations and orbital elements

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Alpha Virginis is a binary system whose proximity and brightness allow detailed investigations of the internal structure and evolution of stars undergoing time-variable tidal interactions. Previous studies have led to the conclusion that the internal structure of Spica's primary star may be more centrally condensed than predicted by theoretical models of single stars, raising the possibility that the interactions could lead to effects that are currently neglected in structure and evolution calculations. The key parameters in confirming this result are the values of the orbital eccentricity e, the apsidal period U, and the primary

star's radius, R1. We analyze the impact that line profile variability has on the derivation of its orbital elements and R1. We use high SNR observations obtained in 2000, 2008, and 2013 to derive the orbital elements from fits to the radial velocity curves. We produce synthetic line profiles using an ab initio tidal interaction model. Results: The variations in the line profiles can be understood in terms of the tidal flows, whose large-scale structure is relatively fixed in the rotating binary system reference frame. Fits to the radial velocity curves yield e=0.108+/-0.014. However, the analogous RV curves from theoretical line profiles indicate that the distortion in the lines causes the fitted value of e to depend on the argument of periastron; i.e., on the epoch of observation. As a result, the actual value of e may be as high as 0.125. We find that U=117.9+/-1.8, which is in agreement with previous determinations. Using the value R1=6.8 Ro derived by Palate et al. (2013) the value of the observational internal structure cinstant k_{2,obs} is consistent with theory. We confirm the presence of variability in the line profiles of the secondary star.

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On the Social Traits of Luminous Blue Variables

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In a recent paper, Smith and Tombleson (2015) state that the Luminous Blue Variables (LBVs) in the Milky Way and the Magellanic Clouds are isolated; that they are not spatially associated with young O-type stars. They propose a novel explanation that would overturn the standard view of LBVs. In this paper we test their hypothesis for the LBVs in M31 and M33 as well as the LMC and SMC. In M31 and M33, the LBVs are associated with luminous young stars and supergiants appropriate to their luminosities and positions on the HR Diagram. Moreover, in the Smith and Tombleson scenario most of the LBVs should be runaway stars, but the stars' velocities are consistent with their positions in the respective galaxies. In the Magellanic Clouds, those authors' sample was a mixed population. We reassess their analysis, removing seven stars that have no clear relation to LBVs. When we separate the more massive classical and the less luminous LBVs, the classical LBVs have a distribution similar to the late O-type stars, while the less luminous LBVs have a distribution like the red supergiants. None of the confirmed LBVs have high velocities or are candidate runaway stars. These results support the accepted description of LBVs as evolved massive stars that have shed a lot of mass, and are now close to their Eddington limit.

Reference: The Astrophysical Journal
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1603.01278

Comments:

Email: roberta@umn.edu

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Luminous and Variable Stars in M31 and M33. III. The Yellow and Red Supergiants and Post-Red Supergiant Evolution

Michael S. Gordon, Roberta M. Humphreys, and Terry J. Jones

Minnesota Institute for Astrophysics, University of Minnesota

Recent supernova and transient surveys have revealed an increasing number of non-terminal stellar eruptions. Though the progenitor class of these eruptions includes the most luminous stars, little is known of the pre-supernova mechanics of massive stars in their most evolved state, thus motivating a census of possible progenitors. From surveys of evolved and unstable luminous star populations in nearby galaxies, we select a sample of yellow and red supergiant candidates in M31 and M33 for review of their spectral characteristics and spectral energy distributions. Since the position of intermediate and late-type supergiants on the color-magnitude diagram can be heavily contaminated by foreground dwarfs, we employ spectral classification and multi-band photometry from optical and near-infrared surveys to confirm membership. Based on spectroscopic evidence for mass loss and the presence of circumstellar dust in their SEDs, we find that 30-40% of the yellow supergiants are likely in a post-red supergiant state. Comparison with evolutionary tracks shows that these mass-losing, post-RSGs have initial masses between 20-40 Msun. More than half of the observed red supergiants in M31 and M33 are producing dusty circumstellar ejecta. We also identify two new warm hypergiants in M31, J004621.05+421308.06 and J004051.59+403303.00, both of which are likely in a post-RSG state.

Reference: The Astrophysical Journal
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1603.08003

Comments:

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Abstracts of 2 conference proceedings

Complete proceedings of the Potsdam Wolf-Rayet Workshop 2015 now available

W.-R. Hamann, A. Sander, and H. Todt

Institut fuer Physik und Astronomie, Universitaet Potsdam, Germany

After careful editing and printing, the complete proceedings of the Wolf-Rayet Workshop 2015 in Potsdam are now available online. For all participants, a printed copy has been sent out.

Apart from the total volume, each of the single contributions are also available for free via ADS or the university publisher interface at
https://publishup.uni-potsdam.de/solrsearch/index/search/searchtype/collection/id/17262

Proceedings abstract:

Nearly 150 years ago, the French astronomers Charles Wolf and Georges Rayet described stars with very conspicuous spectra that are dominated by bright and broad emission lines. Meanwhile termed Wolf-Rayet Stars after their discoverers, those objects turned out to represent important stages in the life of massive stars.

As the first conference in a long time that was specifically dedicated to Wolf-Rayet stars, an international workshop was held in Potsdam, Germany, from 1.-5. June 2015. About 100 participants, comprising most of the leading experts in the field as well as as many young scientists, gathered for one week of extensive scientific exchange and discussions. Considerable progress has been reported throughout, e.g. on finding such stars, modeling and analyzing their spectra, understanding their evolutionary context, and studying their circumstellar nebulae. While some major questions regarding Wolf-Rayet stars still remain open 150 years after their discovery, it is clear today that these objects are not just interesting stars as such, but also keystones in the evolution of galaxies.

These proceedings summarize the talks and posters presented at the Potsdam Wolf-Rayet workshop. Moreover, they also include the questions, comments, and discussions emerging after each talk, thereby giving a rare overview not only about the research, but also about the current debates and unknowns in the field. The Scientific Organizing Committee (SOC) included Alceste Bonanos (Athens), Paul Crowther (Sheffield), John Eldridge (Auckland), Wolf-Rainer Hamann (Potsdam, Chair), John Hillier (Pittsburgh), Claus Leitherer (Baltimore), Philip Massey (Flagstaff), George Meynet (Geneva), Tony Moffat (Montreal), Nicole St-Louis (Montreal), and Dany Vanbeveren (Brussels).

Reference: Electronic publication by the Universitätsverlag Potsdam (Potsdam University Press)
Status: Conference proceedings

Weblink: http://adsabs.harvard.edu/abs/2015wrs..conf.....H

Comments: The total volume contains 378 pages and 84 articles including the questions/discussions after each talk.

Email: ansander@astro.physik.uni-potsdam.de

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Giant eruptions of very massive stars

Kris Davidson

University of Minnesota

Giant eruptions or supernova-impostor events are far more mysterious than true supernovae. An extreme example can release as much radiative energy as a SN, ejecting several M_sun of material. These events involve continuous radiation-driven outflows rather than blast waves. They constitute one of the main unsolved problems in stellar astrophysics, but have received surprisingly little theoretical effort. Here I note some aspects that are not yet familiar to most astronomers.

Reference: To appear in Phys. Chem. Late Stages Stellar Evol., 11th Pacific Rim Conf., Hong Kong 2015
Status: Conference proceedings

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JOBS

11 postdoc positions at Instituto de Astrofisica de Canarias

Dr. Enric Palle, IAC Research Head

Instituto de Astrofisica de Canarias
C/ Via Lactea s/n
E-38205 La Laguna, Tenerife
Spain

The IAC offers 11 postdoc positions in the frame of the Severo Ochoa program for excellence research centers in Spain.
Some of the positions are for five years (so-called Severo Ochoa Advanced Fellowships).
The positions cover many different fields in Astrophysics.

Attention/Comments: see the link below for details of each position

Weblink: http://www.iac.es/info.php?op1=26=en

Email: corinv@iac.es

Deadline: may 31, 2016 or july 31, 2016

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Two 3-year postdoctoral positions in stellar modelling

Conny Aerts and Tami Rogers

Institute of Astronomy, University of Leuven, Belgium

Department of Mathematics and Statistics, Newcastle University, UK

Thanks to STFC & ERC funding, Profs Tami Rogers (Newcastle University, UK) and Conny Aerts (Leuven University, B) welcome applications for two postdoctoral positions of 3 years each to work on 3D hydrodynamical simulations of massive stars and their signature in modern observations and in 1D stellar models. The postdocs will work in close collaboration with the two PIs and with four PhD students (2 in Newcastle and 2 in Leuven).

Application deadline: 1 July 2016.

Start of the positions: ideally between 1 September and 1 December 2016.

Review of applications will start early July 2016.

Attention/Comments: The two positions require separate applications.

Postdoc vacancy at Newcastle University, UK:
https://vacancies.ncl.ac.uk/ViewVacancyV2.aspx?enc=mEgrBL4XQK0+ld8aNkwYmARQe8VyurAyTH4BnG2cTVTglCZNptYX3gaQgAQkznbZUDvoIjA3C94RqL5R7p005vlMgM4/4/6eGL5lwEzMOAosVtYZT35LeankA+JWKVhHec+zs2jkqKzMwnhf5exSao8lw9nkPCUpD9mF24s4T1sF2L5YCUK1j2ftceTmiHDn

Postdoc vacancy at Leuven University, B:
http://jobregister.aas.org/job_view?JobID=53969

Weblink:

Email: conny.aerts@ster.kuleuven.be

Deadline: 1 July 2016

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Closed Job Offers

Postdoctoral position on Gaia and massive stars

Dr. Eric Gosset and Prof. Gregor Rauw

Institute of Astrophysics and Geophysics
Quartier Agora, Batiment B5c
Allee du 6 Aout, 19c
4000 Liege
Belgium

The High-Energy Astrophysics Group (http://www.gaphe.ulg.ac.be/index_e.html) of the Department of Astrophysics, Geophysics and Oceanography (http://www.ago.ulg.ac.be/index_e.php) of the University of Liege (Belgium) is offering a postdoctoral position to participate in the development of projects related to massive stars and the ESA cornerstone mission Gaia. The position is funded by Concerted Research Actions (ARC) programme.

The High-Energy Astrophysics Group (GAPHE) carries out a variety of research projects aiming at studying single and binary massive stars (OB, Wolf-Rayet, Luminous Blue Variables, ...) and the interactions with their environment based on data obtained with world-class, space-borne (XMM, Chandra, ...) or ground-based (ESO, ...) facilities.

The Gaia satellite is currently performing an all-sky survey providing astrometry and photometry for about one billion stars, and spectroscopy for a subsample. The first data are due to be released to the whole community in summer 2016. This release will include parallaxes and proper motions of unprecedented accuracy for about 2.5 million bright sources (see http://www.cosmos.esa.int/web/gaia/release), among which a large number of massive stars. On the other hand, members of the GAPHE are involved in the Gaia-ESO survey (https://www.gaia-eso.eu/), whose main goal is to complement the Gaia data by providing precise chemical abundances. As part of this survey, spectroscopic data are being collected for numerous hot stars in young open clusters (Carina Nebula, ...).

The successful candidate will develop projects making use of the data for hot stars from the first (2016) and second (2017) Gaia data releases. In parallel, he/she is expected to analyse the data for OB stars obtained by the Gaia-ESO survey, with a particular emphasis on the determination of the atmospheric

parameters, chemical composition and wind properties.

Applicants with interest and previous experience in massive star research are invited to apply. Expertise in the determination of fundamental parameters and abundances of massive stars, analysis of spectroscopic data, knowledge of model atmosphere codes for hot stars (CMFGEN, TLUSTY, ...) and astronomical softwares (IRAF, MIDAS, ...) are an advantage but are not mandatory.

Applicants should have a record of publications in peer-reviewed journals, demonstrated creativity, independence, high motivation, good communication skills, and the ability to work independently as well as in collaboration with other members of our research group.

The appointment is initially for one year with a possible extension for a second year subject to funding and performance. The starting date is negotiable but preferably before June 1st, 2016. To be eligible, the applicant should not have lived or worked in the 'Federation Wallonie-Bruxelles' for more than 24 months over the last three years. The salary is on the official Belgian public employee pay scale for a young Post-Doc. Funding for travel and research equipment is available.

Interested persons should send their application material including a curriculum vitae, a summary (one page at most) of past and current research activities, a letter of interest, a full publication list and a list of three reference persons by e-mail to: Eric Gosset/Gregor Rauw, Institute of Astrophysics and Geophysics, Quartier Agora, Batiment B5c, Allee du 6 Aout, 19c, 4000 Liege, Belgium (e-mail: gosset@astro.ulg.ac.be, rauw@astro.ulg.ac.be). The application deadline is May 1st, 2016. For any further inquiry, please e-mail: gosset@astro.ulg.ac.be.

Attention/Comments:

Weblink: http://www.ago.ulg.ac.be/Edu/Jobs/Job_54.pdf

Email: gosset@astro.ulg.ac.be

Deadline: May 1st, 2016

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MEETINGS

IAUS 329: The Lives and Death-Throes of Massive Stars

28th November to 2nd December 2016

Venue: The Spencer on Byron Hotel, Takapuna, Auckland, New Zealand

Dear colleagues,

This is the second announcement of the forthcoming IAU symposium to be held in Auckland, New Zealand entitled
"IAUS 329: The Lives and Death-Throes of Massive Stars".

Dates: 28th November to 2nd December 2016
Location: Auckland, New Zealand
Venue: The Spencer on Byron Hotel, Takapuna

Registration, abstract submission and application for IAU travel grants are now open.

Abstract Submission closes: 30th May 2016
IAU travel grant Submission closes: 30th May 2016
Early-bird registration closes: 30th August 2016

Conference website: http://nzstars2016.nz

Contact for questions about the meeting scientific program: nzstars2016@auckland.ac.nz

The meeting will summarize recent progress and establish stronger links between the massive star community and closely-linked fields, particularly those studying end stages of massive star evolution and massive star cosmic implications.

Topics to be covered:
Death throes: supernovae, stellar deaths and progenitors
Observations and surveys of massive stars: hot stars, cool stars, transition objects and binaries
Theory of stellar evolution & atmospheres: beyond standard physics, rotation, duplicity, mass loss and magnetic fields and instabilities
Massive stars and their supernovae as galactic building blocks and engines: Milky Way, nearby galaxies and the early Universe
Invited Speakers

Evelyne Alecian, Rodolfo Barba, Kris Belczynski, Melina Bersten, Saida Caballero-Nieves, Luc Dessart, Morgan Fraser, Miriam Garcia, Cyril Georgy, Goetz Grafener, Jose Groh, Stephen Justham, Emily Levesque, Georges Meynet, Shazrene Mohamed, Bernhard Muller, Ignacio Negureruela, Maria Fernanda Nieva, Keiichi Ohnaka, Hugues Sana, Andreas Sander, Sergio Simon-Diaz, Alicia Soderberg, Elizabeth Stanway, Miguel Urbaneja

Travel, accommodation and support

New Zealand is a significant distance to travel, particularly due to the location of the international date line causing many attendees to "lose-a-day" when travelling to the conference. We advise our most distant attendees to arrive two days early, if possible, but at least 1 day before the Monday morning, so they are able to enjoy the first full day of the conference.

Rooms can be booked directly at the hotel as described on the conference website. It is possible for two or three people to share one room. We suggest attendees organise their own groups. We will attempt to provide a way to find roommates on the conference website shortly, this can also be done via the conference's facebook group.

We are also attempting to obtain access to discounts on flights. We will update the conference website with details of this hopefully in the next few weeks.

We have limited funds from the IAU to provide support for attendees that have limited travel funding. Details on how to apply for this are on the conference website.

If you require a letter of invitation to visit New Zealand, you must first register for and pay all applicable registration fees. Full details of how to apply for this letter and a list of visa-free countries are listed on the conference website.

Nationwide public symposium

In the weekend following the conference, Dec 3rd, we are planning to run a large one day public symposium with as many speakers as possible talking about their latest research. We also hope to have these talks streamed live onto the internet and recorded so there is a lasting impact of the meeting in New

Zealand. If you would like to be involved, or perhaps to travel to a city within New Zealand to give a talk please email nztars2016@auckland.ac.nz and outline your previous outreach experience.

Splinter Meetings

It may be possible to run a few splinter meetings during the conference in the evenings, or during the weekend after the main conference. If you would like to run a splinter meeting please email nztars2016@auckland.ac.nz with a short outline of the topic, an estimated number of participants, and the names of organizers before the 30th May 2016.

Conference Excursions

There are currently two excursions planned for the Wednesday afternoon of the conference. One is a trip to Rangitoto Island, the volcano that is visible from the hotel. This costs NZ$92 and lasts from11.45am to approximately 5.15pm - includes round trip coach transfers (from the hotel to Ferry Terminal, Ferry to the island and tour escort. While it's not a walk for the faint-hearted, it is family friendly. Make sure you arrive prepared – there are no shops or transport on the island and limited drinking water. Bring sunblock and a hat and wear comfortable walking shoes. Alternatively there is a trip to the Auckland War Memorial Museum which will cost NZ$72. The trip runs from 1.15pm to approximately 4.15pm - includes round trip coach transfers, tour guide and entry to museum.

Social Media

The hashtag for the meeting is #NZstars2016. We have also setup a Facebook group for the meeting which can be found at: https://www.facebook.com/groups/1015095635200645/

Conference Equity and Anti-Harassment Statement

#NZstars2016 is dedicated to providing an equitable and harassment-free conference experience for everyone regardless of gender, gender identity and expression, sexual orientation, disability, physical appearance, body size, race, age or religion. We do not tolerate harassment of conference participants in any form. Conference participants violating these rules may be sanctioned at the discretion of the conference organizers and the conference equity committee.

Weblink: nzstars2016.nz

Email: nzstars2016@auckland.ac.nz

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