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THE MASSIVE STAR NEWSLETTER

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Accepted Papers

Modeling the RXTE light curve of eta Carinae from a 3-D SPH simulation of its binary wind collision

A.T. Okazaki, S.P. Owocki, C.M. Russell, and M.F. Corcoran

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2,3- University of Delaware, Newark, DE USA

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The very massive star system eta Carinae exhibits regular 5.54-year (2024-day) period disruptive events in wavebands ranging from the radio to X-ray. There is a growing consensus that these events likely stem from periastron passage of an (as yet) unseen companion in a highly eccentric ($\epsilon \sim$=0.9) orbit. This paper presents three-dimensional (3-D) Smoothed Particle Hydrodynamics (SPH) simulations of the orbital variation of the binary wind-wind collision, and applies these to modeling the X-ray light curve observed by the Rossi X-ray Timing Explorer (RXTE). By providing a global 3-D model of the phase variation of the density of the interacting winds, the simulations allow computation of the associated variation in absorption of X-ray emission, presumed here to originate from near the apex of the wind-wind interaction cone. We find that the observed RXTE light curve can be readily fit if the observer's line of sight is within this cone along the general direction of apastron. Specifically, the data are well fit by an assumed inclination i=45 deg for the orbit's polar axis, which is thus consistent with orbital angular momentum being along the inferred polar axis of the Homunculus nebula. The

fits also constrain the position angle ϕ that an orbital-plane projection makes with the apastron side of the semi-major axis, strongly excluding positions $\phi < 9$ deg along or to the retrograde side of the axis, with the best fit position given by $\phi = 27$ deg. Overall the results demonstrate the utility of a fully 3-D dynamical model for constraining the geometric and physical properties of this complex colliding-wind binary system.

Reference: MNRAS, accepted 12May08

On the web at:
`http://www.bartol.udel.edu/~owocki/preprints/Okazaki-MNRAS-SPH-RXTE-May08.pdf`

Preprints from: `owocki@bartol.udel.edu`

Galaxies with Wolf-Rayet signatures in the low-redshift Universe - A survey using the Sloan Digital Sky Survey

J. Brinchmann (1, 2), D. Kunth (3), F. Durret (3)

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We have carried out a search for Wolf-Rayet galaxies in all galaxies with EW(Hb)>2 Å in the SDSS DR6. We identify Wolf-Rayet features using a mixture of automatic and visual classification and find a total of 570 galaxies with significant Wolf-Rayet (WR) features and a further 1115 potential candidates, several times more than even the largest heterogeneously assembled catalogues. We discuss in detail the properties of galaxies showing Wolf-Rayet features with a focus on their empirical properties. We are able to accurately quantify the incidence of Wolf-Rayet galaxies with redshift and show that the likelihood of otherwise similar galaxies showing Wolf-Rayet features increases with increasing metallicity, but that WR features are found in galaxies of a wide range in morphology. The large sample allows us to show explicitly that there are systematic differences in the metal abundances of WR and non-WR galaxies. The most striking result is that, below EW(Hb)=100Å, Wolf-Rayet galaxies show an elevated N/O relative to non-WR galaxies. We interpret this as a rapid enrichment of the ISM from WR winds. We also show that the model predictions for WR features strongly disagree with the observations at low metallicity; while they do agree quite well with the data at solar abundances. We discuss possible reasons for this and show that models incorporating binary evolution reproduce the low-metallicity results reasonably well. Finally we combine the WR sample with a sample of galaxies with nebular He II 4686 to show that, at 12 + log O/H < 8, the main sources of He II ionising photons appears to be O stars, arguing for a less dense stellar wind at these metallicities, while at higher abundances WN stars might increasingly dominate the ionisation budget.

Reference: Accepted for A&A

Comments: We are also in the process of establishing a web page which will contain more information (images, placement of spectroscopic fibre etc) than in the published paper. This can be accessed at:

http://www.strw.leidenuniv.nl/~jarle/WRinSDSS/

On the web at: `http://uk.arxiv.org/abs/0805.1073`

Preprints from: `jarle@strw.leidenuniv.nl`

A 3D dynamical model of the colliding winds in binary systems

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University of Leeds

We present a 3D dynamical model of the orbital induced curvature of the wind-wind collision region in binary star systems. Momentum balance equations are used to determine the position and shape of the contact discontinuity between the stars, while further downstream the gas is assumed to behave ballistically. An archimedean spiral structure is formed by the motion of the stars, with clear resemblance to high resolution images of the so-called "pinwheel nebulae". A key advantage of this approach over grid or smoothed particle hydrodynamic models is its significantly reduced computational cost, while it also allows the study of the structure obtained in an eccentric orbit. The model is relevant to symbiotic systems and Gamma-ray binaries, as well as systems with O-type and Wolf-Rayet stars.

As an example application, we simulate the X-ray emission from hypothetical O+O and WR+O star binaries, and describe a method of ray tracing through the 3D spiral structure to account for absorption by the circumstellar material in the system. Such calculations may be easily adapted to study observations at wavelengths ranging from the radio to Gamma-ray.

Reference: Accepted by MNRAS

Comments: 16 pages, 24 figures

On the web at: `http://arxiv.org/abs/0805.4529`

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

The neon content of nearby B-type stars and its implications for the solar model problem

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The recent downward revision of the solar photospheric abundances now leads to severe inconsistencies between the theoretical predictions for the internal structure of the Sun and the results of helioseismology. There have been claims that the solar neon abundance may be underestimated and that an increase in this poorly-known quantity could alleviate (or even completely solve) this problem. Early-type stars in the solar neighbourhood are well-suited to testing this hypothesis because they are the only stellar objects whose absolute neon abundance can be derived from the direct analysis of photospheric lines. Here we present a fully homogeneous NLTE abundance study of the optical Ne I and Ne II lines in a sample of 18 nearby, early B-type stars, which suggests log ϵ[Ne]=7.97+/-0.07 dex (on the scale in which log ϵ[H]=12) for the present-day neon abundance of the local ISM. Chemical evolution models of the Galaxy only predict a very small enrichment of the nearby interstellar gas in neon over the past 4.6 Gyr, implying that our estimate should be representative of the Sun at birth. Although higher by about 35% than the new recommended solar abundance, such a value appears insufficient by itself to restore the past agreement between the solar models and the helioseismological constraints.

Reference: To appear in A&A.
Comments: Contains colour figures.

On the web at: http://www.ster.kuleuven.be/∼thierry/preprints.html

Preprints from: morel@astro.ulg.ac.be

The very massive binary NGC3603-A1

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Using VLT/SINFONI, we have obtained repeated AO-assisted, NIR spectroscopy of the three central WN6ha stars in the core of the very young (∼1 Myr), massive and dense Galactic cluster NGC3603. One of these stars, NGC3603-A1, is a known 3.77-day, double-eclipsing binary, while another one, NGC3603-C, is one of the brightest X-ray sources among all known Galactic WR stars, which usually is a strong indication for binarity. Our study reveals that star C is indeed an 8.9-day binary, although only the WN6ha component is visible in our spectra; therefore we temporarily classify star C as an SB1 system. A1, on the other hand, is found to consist of two emission-line stars of similar, but not necessarily of identical spectral type, which can be followed over most the orbit. Using radial velocities for both components and the previously known inclination angle of the system, we are able to derive absolute masses for both stars in A1. We find $M_1 = (116 \pm 31)$ Mo for the primary and $M_2 = (89 \pm 16)$ Mo for the secondary component of A1. While uncertainties are large, A1 is intrinsically half a magnitude brighter than WR20a, the current record holder with 83 and 82 Mo, respectively; therefore, it is likely that the primary in A1 is indeed the most massive star weighed so far.

Reference: MNRAS Letters

On the web at: http://arxiv.org/abs/0806.2815

Preprints from: o.schnurr@sheffield.ac.uk

A Spectroscopic Survey of WNL Stars in the LMC: General Properties and Binary Status

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(3) Las Campanas Observatory, Chile

(4) Instituto de Astrofísica de Andalucía, Spain

We report the results of an intense, spectroscopic survey of all 41 late-type, nitrogen-rich Wolf-Rayet (WR) stars in the Large Magellanic Cloud (LMC) observable with ground-based telescopes. This

survey concludes the decade-long effort of the Montréal Massive Star Group to monitor every known WR star in the Magellanic Clouds except for the 6 crowded WNL stars in R136, which will be discussed elsewhere. The focus of our survey was to monitor the so-called WNL stars for radial-velocity (RV) variability in order to identify the short- to intermediate-period ($P \lesssim 200$ days) binaries among them. Our results are in line with results of previous studies of other WR subtypes, and show that the binary frequency among LMC WNL stars is statistically consistent with that of WNL stars in the Milky Way. We have identified four previously unknown binaries, bringing the total number of known WNL binaries in the LMC to nine. Since it is very likely that none but one of the binaries are classical, helium-burning WNL stars, but rather superluminous, hence extremely massive, hydrogen-burning objects, our study has dramatically increased the number of known binaries harbouring such objects, and thus paved the way to determine their masses through model-independent, Keplerian orbits. It is expected that some of the stars in our binaries will be among the most massive known. With the binary status of each WR star now known, we also studied the photometric and X-ray properties of our program stars using archival MACHO photometry as well as Chandra and ROSAT data. We find that one of our presumably single WNL stars is among the X-ray brightest WR sources known. We also identify a binary candidate from its RV variability and X-ray luminosity which harbours the most luminous WR star known in the Local Group.

Reference: MNRAS

On the web at: `http://arxiv.org/abs/0806.2801`

Preprints from: `o.schnurr@sheffield.ac.uk`

From B[e] to A[e]. On the peculiar variations of the SMC supergiant LHA 115-S 23 (AzV 172)

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Optical observations from 1989 of the Small Magellanic Cloud (SMC) B[e] supergiant star LHA 115-S 23 (in short: S 23) revealed the presence of photospheric HeI absorption lines, classifying S 23 as a B8 supergiant. In our high-resolution optical spectra from 2000, however, we could not identify any HeI line. Instead, the spectral appearance of S 23 is more consistent with the classification as an A1 supergiant, maintaining the so-called B[e] phenomenon. The observed changes in spectral behaviour of S 23 lead to different spectral classifications at different observing epochs. The aim of this research is, therefore, to find and discuss possible scenarios that might cause a disappearance of the photospheric HeI absorption lines within a period of only 11 years. From our high-resolution optical spectra, we perform a detailed investigation of the different spectral appearances of S 23 based on modern and revised classification schemes. In particular, we derive the contributions caused by the interstellar as well as the circumstellar extinction self-consistently. The latter is due to a partly optically thick wind. We further determine the projected rotational velocities of S 23 in the two epochs of spectroscopic observations. Based on its spectral appearance in 2000, we classify S 23 as A1 Ib star with an effective temperature of about 9000 K. This classification is supported by the additional

analysis of the photometric UBV data. An interstellar extinction value of $E(B-V) \simeq 0.03$ is derived. This is considerably lower than the previously published value, which means that, if the circumstellar extinction due to the stellar wind is neglected, the interstellar extinction, and hence the luminosity of the star, are overestimated. We further derive a rotation velocity of $vsini \simeq 150\,\mathrm{km\,s^{-1}}$, which means that S 23 is rotating with about 75% of its critical speed. The object S 23 is thus the fourth B[e] supergiant with confirmed high projected rotational velocity. The most striking result is the apparent cooling of S 23 by more than 1500 K with a simultaneous increase of its rotation speed by about 35% within only 11 years. Since such a behaviour is excluded by stellar evolution theories, we discuss possible scenarios for the observed peculiar variations in S 23.

Reference: Astronomy & Astrophysics

On the web at: `http://arxiv.org/abs/0806.3208`

Preprints from: `kraus@sunstel.asu.cas.cz`

Spectroscopic and photometric variability of the O9.5Vp star HD93521

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3 - Departamento de Astronomia, Universidad de Guanajuato, Mexico

The line profile variability and photometric variability of the O9.5Vp star HD93521 are examined in order to establish the properties of the non-radial pulsations in this star. Fourier techniques are used to characterize the modulations of the He I 5876, 6678 and H-alpha lines in several spectroscopic time series and to search for variations in a photometric time series. Our spectroscopic data confirm the existence of two periods of 1.75 and 2.89 hr. The line profiles, especially those affected by emission wings, exhibit also modulations on longer time scales, but these are epoch-dependent and change from line to line. Unlike previous claims, we find no unambiguous signature of the rotational period in our data, nor of a third pulsation period (corresponding to a frequency of 2.66 day^{-1}). HD93521 very likely exhibits non-radial pulsations with periods of 1.75 and 2.89 hr with $l \simeq 8 \pm 1$ and $l \simeq 4 \pm 1$ respectively. No significant signal is found in the first harmonics of these two periods. The 2.89 hr mode is seen at all epochs and in all lines investigated, while the visibility of the 1.75 hr mode is clearly epoch dependent. Whilst light variations are detected, their connection to these periodicities is not straightforward.

Reference: Astronomy & Astrophysics, in press

On the web at: `arxiv.org/abs/0806.3640`

Preprints from: `rauw@astro.ulg.ac.be`

Classification and Discovery with Large Astronomical Surveys

14-17 October 2008
Ringberg Castle, Germany

Numerous current or upcoming astronomical surveys produce large amounts of photometric, spectroscopic and astrometric data. Object classification, parameter determination, novelty detection and the discovery of structure are important yet challenging tasks. This workshop will bring together scientists to discuss the issues, present algorithms and results, and identify common problems and solutions for future work.

We invite scientists from all areas of astronomy working on the analysis and interpretation of large astronomical datasets to submit an abstract. This will be an informal meeting with a maximum of 60 participants. Print and online proceedings will be published by the American Institute of Physics.

The workshop will take place at Ringberg Castle in the foothills of the Bavarian Alps. There will be plenty of time for discussions, both during the plenary sessions as well as in the dining room, bar and lounges in the castle. Up to 34 participants can be hosted at the castle itself (first-come, first-served) with the rest staying at a hotel in a nearby town.

For more details on the workshop goals, list of invited speakers, plus registration and other practical information, see the web page listed below.

Weblink: `http://www.mpia.de/class2008/`

Email contact: `class2008@mpia-hd.mpg.de`

Hot And Cool: Bridging Gaps in Massive Star Evolution (UPDATE - WEBSITE AVAILABLE)

10 - 12 November 2008
Pasadena, CA

Addendum to the previous submission: the website for this meeting is up and running.
See http://www.ipac.caltech.edu/hotandcool/CoolAndHot.html.

Weblink: `http://www.ipac.caltech.edu/hotandcool/CoolAndHot.html`

Email contact: `leitherer@stsci.edu`