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THE MASSIVE STAR NEWSLETTER

formerly known as the hot star newsletter

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New IAU Commission on Massive Stars (Commission C.G2)

dear friends and colleagues,

welcome to our first Massive Star Newsletter as the new IAU Commission on Massive Stars (Commission C.G2). I would like to thank you all for your support during the process of becoming a Commission and congratulate us all for the success of our proposal.

The web page and the Massive Star Newsletter will continue hosted in the UNAM (thanks to Gloria Koenigsberger and the UNAM people) edited by Raphael Hirschi and Philippe Eenens (thanks to them as well). Therefore you can continue submitting your abstracts, job offers, news and announcements in the same way as before. In the near future, of course, the web page will experience some updates and changes.

The Organizing Committee will be formed by Artemio Herrero (President), Jorick Vink (Vice-president and future president), Nicole St.-Louis and Gregor Rauw (Commission proponents) and Jose Groh, You-Hua Chu and Asif ud-Doula (elected members).

The old Working Group has disappeared, and those of you who are not IAU members cannot be part of the new Commission. The IAU has lowered the requirements to become a member. Please, check whether you can become an IAU member (if you are not) and join our Commission. Nevertheless, the services on our web page will continue for all people registered in the web page, and new registrations are open. We hope that the change will be transparent to most of you.

Becoming a Commission is a recognition of the work done by the members of the Massive Stars Working Group and will give our community more weight in the IAU structure. We shall see this new status as an opportunity to promote the role of Massive Stars in Astrophysics and their links to other fields.

with best regards,

Artemio Herrero

President, on behalf of the Organizing Committee of the IAU Commission on Massive Stars

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ASR Special Issue "X-rays from hot stars"

Original contributions and reviews of X-ray emission from hot stars and their winds, are solicited for a special topical issue of
Advances in Space Research. Given large interest and in response to multiple requests the deadline for submission is extended to 1st September 2015.

This special issue is aimed to summarize our current knowledge of X-ray emission from hot stars as well as open new avenues and perspectives in anticipation of the next generation of X-ray telescopes.

The manuscript submission site is at http://ees.elsevier.com/jasr/ (Advances in Space Research). Please select "X-ray Emission: Hot Stars" in the special issue drop-down for article type. Submitted papers must be written in English. Only full-length papers will be considered for publication, subject to peer review by two reviewers. There are no page limits although the length of the paper should be appropriate for the material being presented. The deadline for submissions is 1 September 2015. Papers will be published electronically as soon as they are accepted. The printed issue will be assembled within a reasonable time.

We are looking forward to receiving your manuscript.

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Fizeau exchange visitors program - call for applications

J. Hron & L. Misoni

European Interferometry Initiative

Dear colleagues!

The Fizeau exchange visitors program in optical interferometry funds (travel and accommodation) visits of researchers to an institute of his/her choice (within the European Community) to perform collaborative work and training on one of the active topics of the European Interferometry Initiative. The visits will typically last for one month, and strengthen the network of astronomers engaged in technical, scientific and training work on optical/infrared interferometry. The program is open for all levels of astronomers (Ph.D. students to tenured staff), non-EU based missions will only be funded if considered essential by the Fizeau Committee. Applicants are strongly encouraged to seek also partial support from their home or host institutions.

The deadline for applications is September 15. Fellowships can be awarded for missions starting in November.

Further informations and application forms can be found at
www.european-interferometry.eu

The program is funded by OPTICON/FP7.

Please distribute this message also to potentially interested colleagues outside of your community!

Looking forward to your applications,
Josef Hron & Laszlo Mosoni
(for the European Interferometry Initiative)

Reference: www.european-interferometry.eu
Status: Other

Weblink: www.european-interferometry.eu

Comments:

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PAPERS

Abstracts of 17 accepted papers

UV and X-ray monitoring of CPD -28 2561

Naze, Yael (1); Sundqvist, Jon O. (2,3); Fullerton, Alex W. (4); ud-Doula, Asif (5); Wade, Gregg A. (6); Rauw, Gregor (1); Walborn, Nolan R. (4)

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The Of?p star CPD -28 2561 was monitored at high energies with XMM-Newton and HST. In X-rays, this magnetic oblique rotator displays bright and hard emission that varies by ~55% with rotational phase. These changes occur in phase with optical variations, as expected for magnetically confined winds; there are two maxima and two minima in X-rays during the 73d rotational period of CPD -28 2561. However, contrary to previously studied cases, no significant hardness variation is detected between minima and maxima, with the exception of the second minimum which is slightly distinct from the first one. In the UV domain, broad-band fluxes remain stable while line profiles display large variations. Stronger absorptions at low velocities are observed when the magnetic equator is seen edge-on, which can be reproduced by a detailed 3D model. However, a difference in absorption at high velocities in the CIV and NV lines is also detected for the two phases where the confined wind is seen nearly pole-on. This suggests the presence of strong asymmetries about the magnetic equator, mostly in the free-flowing wind (rather than in the confined dynamical magnetosphere).

Reference: accepted by MNRAS
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1506.08572

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A Consistent Spectral Model of WR 136 and its Associated Bubble NGC 6888

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We analyse whether a stellar atmosphere model computed with the code CMFGEN provides an optimal description of the stellar observations of WR 136 and simultaneously reproduces the nebular observations of NGC 6888, such as the ionization degree, which is modelled with the pyCloudy code. All the observational material available (far and near UV and optical spectra) were used to constrain such models. We found that even when the stellar luminosity and the mass-loss rate were well constrained, the stellar temperature T_* at tau = 20, can be in a range between 70 000 and 110 000 K. When using the nebula as an additional restriction we found that the stellar models with T_* sim 70 000 K represent the best solution for both, the star and the nebula. Results from the photoionization model show that if we consider a chemically homogeneous nebula, the observed N+/O+ ratios found in different nebular zones can be reproduced, therefore it is not necessary to assume a chemical inhomogeneous nebula. Our work shows the importance of calculating coherent models including stellar and nebular constraints. This allowed us to determine, in a consistent way, all the physical parameters of both the star and its associated nebula. The chemical abundances derived are 12 + log(N/H) = 9.95, 12 + log(C/H) = 7.84 and 12 + log(O/H) = 8.76 for the star and 12 + log(N/H) = 8.40, 12 + log(C/H) = 8.86 and 12 + log(O/H) = 8.20. Thus the star and the nebula are largely N- and C- enriched and O-depleted.

Reference: accepted by MNRAS
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1507.00051

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Massive stars on the verge of exploding: The properties of oxygen-sequence Wolf-Rayet stars

Tramper, F.(1); Straal, S. M.(1,2); Sanyal, D(3).; Sana, H.(4); de Koter, A.(1,5); Gräfener, G.(6); Langer, N.(3); Vink, J. S.(6); de Mink, S. E.(1); Kaper, L.(1)

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Context. Oxygen sequence Wolf-Rayet (WO) stars represent a very rare stage in the evolution of massive stars. Their spectra show strong emission lines of helium-burning products, in particular highly ionized carbon and oxygen. The properties of WO stars can be used to provide unique constraints on the (post-)helium burning evolution of massive stars, as well as their remaining lifetimes and the expected properties of their supernovae. Aims. We aim to homogeneously analyze the currently known presumed-single WO stars to obtain the key stellar and outflow properties and to constrain their evolutionary state. Methods. We use the line-blanketed non-local thermal equilibrium atmosphere code cmfgen to model the X-Shooter spectra of the WO stars and deduce their atmospheric parameters. We calculate dedicated evolutionary models to determine the evolutionary state of the stars. Results. The WO stars have extremely high temperatures that range from 150 kK to 210 kK, and have very low surface helium mass fractions that range from 44% down to 14%. Their properties can be reproduced by evolutionary models with helium zero-age main sequence masses of M(He,ini) = 15-25M sun that exhibit fairly strong (a few times 10?^5 Msun/yr?), homogeneous (fc > 0.3) stellar winds. Conclusions. WO stars represent the final evolutionary stage of stars with estimated initial masses of Mini = 40-?60Msun. They are post core-helium burning and predicted to explode as type Ic supernovae within a few thousand years.

Reference: Accepted by A&A
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1507.00839

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Spectral Variations of Of?p Oblique Magnetic Rotator Candidates in the Magellanic Clouds

Nolan R. Walborn (1), Nidia I. Morrell (2), Yael Naze (3), Gregg A. Wade (4), Stefano Bagnulo (5), Rodolfo H. Barba (6), Jesus Maiz Apellaniz (7), Ian D. Howarth (8), Christopher J. Evans (9), Alfredo Sota (10)

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Optical spectroscopic monitoring has been conducted of two O stars in the Small and one in the Large Magellanic Cloud, the spectral characteristics of which place them in the Of?p category, which has been established in the Galaxy to consist of oblique magnetic rotators. All of these Magellanic stars show systematic spectral variations typical of the Of?p class, further strengthening their magnetic candidacy to

the point of virtual certainty. The spectral variations are related to photometric variations derived from OGLE data by Naze et al. (2015) in a parallel study, which yields rotational periods for two of them. Now circular spectropolarimetry is required to measure their fields, and ultraviolet spectroscopy to further characterize their low-metallicity, magnetically confined winds, in support of hydrodynamical analyses.

Reference: accepted by AJ
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1507.02434

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Kepler's first view of O-star variability: K2 data of five O stars in Campaign 0 as a proof-of-concept for O-star asteroseismology

Buysschaert, B.; Aerts, C.; Bloemen, S.; Debosscher, J.; Neiner, C.; Briquet, M.; Vos, J.; Papics, P.; Manick, R.; Schmid, V.; Van Winkel, H.; Tkachenko, A.

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We present high-precision photometric light curves of five O-type stars observed with the refurbished {it Kepler/} satellite during its Campaign 0. For one of the stars, we also assembled high-resolution ground-based spectroscopy with the {sc hermes} spectrograph attached to the 1.2-m Mercator telescope. The stars EPIC202060097 (O9.5V) and EPIC202060098 (O7V) exhibit monoperiodic variability due to rotational modulation with an amplitude of 5.6 mmag and 9.3 mmag and a rotation period of 2.63 d and 5.03 d, respectively. EPIC202060091 (O9V) and EPIC202060093 (O9V:pe) reveal variability at low frequency but the cause is unclear. EPIC202060092 (O9V:p) is discovered to be a spectroscopic binary with at least one multiperiodic βCep-type pulsator whose detected mode frequencies occur in the range [0.11,6.99] d−1 and have amplitudes between 0.8 and 2.0 mmag. Its pulsation spectrum is shown to be fully compatible with the ones predicted by core-hydrogen burning O-star models. Despite the short duration of some 33,d and the limited data quality with a precision near 100 μmag of these first K2 data, the diversity of possible causes for O-star variability already revealed from campaigns of similar duration by the MOST and CoRoT satellites is confirmed with {it Kepler}. We provide an overview of O-star space photometry and give arguments why future K2 monitoring during Campaigns 11 and 13 at short cadence, accompanied by time-resolved high-precision high-resolution spectroscopy opens up the possibility of in-depth O-star seismology.

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Status: Manuscript has been accepted

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B fields in OB stars (BOB): Detection of a strong magnetic field in the O9.7 V star HD54879

N. Castro(1), L. Fossati(1), S. Hubrig(2), S. Simon-Diaz(3), M. Scholler(4), I. Ilyin(2), T. A. Carrol(2), N. Langer(1), T. Morel(5), F. R. N. Schneider(1,6), N. Przybilla(7), A. Herrero(3), A. de Koter(8), L. M. Oskinova(9), A. Reisenegger(10), H. Sana(11) and the BOB collaboration

1 - AIfA, 2 - AIP, 3 - IAC-ULL, 4 - ESO, 5 - AGO-ULG, 6 - OXF, 7 - UIBK, 8 - UVA-KU, 9 - Univ. Potsdam, 10 - PUC, 11 - STScI

The number of magnetic stars detected among massive stars is small; nevertheless, the role played by the magnetic field in stellar evolution cannot be disregarded. Links between line profile variability, enhancements/depletions of surface chemical abundances, and magnetic fields have been identified for low-mass B-stars, but for the O-type domain this is almost unexplored. Based on FORS2 and HARPS spectropolarimetric data, we present the first detection of a magnetic field in HD54879, a single slowly rotating O9.7 V star. Using two independent and different techniques we obtained the firm detection of a surface average longitudinal magnetic field with a maximum amplitude of about 600 G, in modulus. A quantitative spectroscopic analysis of the star with the stellar atmosphere code FASTWIND results in an effective temperature and a surface gravity of 33000 K and 4.0 dex. The abundances of carbon, nitrogen, oxygen, silicon, and magnesium are found to be slightly lower than solar, but compatible within the errors. We investigate line-profile variability in HD54879 by complementing our spectra with spectroscopic data from other recent OB-star surveys. The photospheric lines remain constant in shape between 2009 and 2014, although Ha shows a variable emission. The Ha emission is too strong for a standard O9.7 V and is probably linked to the magnetic field and the presence of circumstellar material. Its normal chemical composition and the absence of photospheric line profile variations make HD54879 the most strongly magnetic, non-variable single O-star detected to date.

Reference: http://arxiv.org/abs/1507.03591
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The internal rotation profile of the B-type star KIC 10526294 from frequency inversion of its dipole gravity modes and statistical model comparison

Santiago Andrés Triana, Ehsan Moravveji, Péter Pápics, Conny Aerts, Steven D. Kawaler, Joergen Christensen-Dalsgaard

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The internal angular momentum distribution of a star is key to determine its evolution. Fortunately, the stellar internal rotation can be probed through studies of rotationally-split non-radial oscillation modes. In particular, detection of non-radial gravity modes (g modes) in massive young stars has become feasible recently thanks to the Kepler space mission. Our aim is to derive the internal rotation profile of the Kepler B8V star KIC 10526294 through asteroseismology. We interpret the observed rotational splittings of its dipole g modes using four different approaches based on the best seismic models of the star and their rotational kernels. We show that these kernels can resolve differential rotation the radiative envelope if a smooth rotational profile is assumed and the observational errors are small. Based on Kepler data, we find that the rotation rate near the core-envelope boundary is well constrained to $163pm89$ nHz. The seismic data are consistent with rigid rotation but a profile with counter-rotation within the envelope has a statistical advantage over constant rotation. Our study should be repeated for other massive stars with a variety of stellar parameters in order to deduce the physical conditions that determine the internal rotation profile of young massive stars, with the aim to improve the input physics of their models.

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OBSERVATIONAL CONSEQUENCES OF TURBULENT PRESSURE IN THE ENVELOPES OF MASSIVE STARS

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The major mass fraction of the envelope of hot luminous stars is radiatively stable. However, the partial ionisation of hydrogen, helium and iron gives rise to extended sub-surface convection zones in all of them. In this work, we investigate the effect of the pressure induced by the turbulent motion in these zones based on the mixing length theory, and search for observable consequences. We find that the

turbulent pressure fraction can amount up to 5% in OB supergiants, and to 30% in cooler supergiants. The resulting structural changes are, however, not significantly affecting the evolutionary tracks compared to previous calculations.
Instead, a comparison of macroturbulent velocities derived from high quality spectra of OB stars with the turbulent pressure fraction obtained in corresponding stellar models reveals a strong correlation of these two quantities. We discuss a possible physical connection, and conclude that turbulent pressure fluctuations may drive high-order oscillations, which — as conjectured earlier — manifest themselves as macroturbulence in the photospheres of hot luminous stars.

Reference: ApJ Letters
Status: Manuscript has been accepted

Weblink: http://arxiv.org/pdf/1507.03988.pdf

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Wolf-Rayet stars in the Small Magellanic Cloud: I. Analysis of the single WN stars

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Wolf-Rayet (WR) stars have a severe impact on their environments owing to their strong ionizing radiation fields and powerful stellar winds. Since these winds are considered to be driven by radiation pressure, it is theoretically expected that the degree of the wind mass-loss depends on the initial metallicity of WR stars. Following our comprehensive studies of WR stars in the Milky Way, M31, and the LMC, we derive stellar parameters and mass-loss rates for all seven putatively single WN stars known in the SMC. Based on these data, we discuss the impact of a low-metallicity environment on the mass loss and evolution of WR stars. The quantitative analysis of the WN stars is performed with the Potsdam Wolf-Rayet (PoWR) model atmosphere code. The physical properties of our program stars are obtained from fitting synthetic spectra to multi-band observations. In all SMC WN stars, a considerable surface hydrogen abundance is detectable. The majority of these objects have stellar temperatures exceeding 75 kK, while their luminosities range from 10^5.5 to 10^6.1 Lsun. The WN stars in the SMC exhibit on average lower mass-loss rates and weaker winds than their counterparts in the Milky Way, M31, and the LMC. By comparing the mass-loss rates derived for WN stars in different Local Group galaxies, we conclude that a clear dependence of the wind mass-loss on the initial metallicity is evident, supporting the current paradigm that WR winds are driven by radiation. A metallicity effect on the evolution of massive stars is obvious from the HRD positions of the SMC WN stars at high temperatures and high luminosities. Standard evolution tracks are not able to reproduce these parameters and the observed surface hydrogen abundances. Homogeneous evolution might provide a better explanation for their evolutionary past.

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The VLT-FLAMES Tarantula Survey XXI. Stellar spin rates of O-type spectroscopic binaries

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The initial distribution of spin rates of massive stars is a fingerprint of their elusive formation process. It also sets a key initial condition for stellar evolution and is thus an important ingredient in stellar population synthesis. So far, most studies have focused on single stars. Most O stars are, however, found in multiple systems. By establishing the spin-rate distribution of a sizeable sample of O-type spectroscopic binaries and by comparing the distributions of binary subpopulations with one another and with that of presumed-single stars in the same region, we aim to constrain the initial spin distribution of O stars in binaries, and to identify signatures of the physical mechanisms that affect the evolution of the spin rates of massive stars spin. We use ground-based optical spectroscopy obtained in the framework of the VLT-FLAMES Tarantula Survey (VFTS) to establish the projected equatorial rotational velocities (vrot) for components of 114 spectroscopic binaries in 30 Doradus. The vrot values are derived from the full width at half maximum (FWHM) of a set of spectral lines, using a FWHM vs. vrot calibration that we derive based on previous line analysis methods applied to single O-type stars in the VFTS sample. The overall vrot distribution of the primary stars resembles that of single O-type stars in the VFTS, featuring a low-velocity peak (at $vrot < 200$,kms) and a shoulder at intermediate velocities ($200 < vrot < 300$,kms). The distributions of binaries and single stars, however, differ in two ways. First, the main peak at $vrot sim$100~kms is broader and slightly shifted towards higher spin rates in the binary distribution than that of the presumed-single stars. This shift is mostly due to short-period binaries ($P_mathrm{orb} lesssim 10$~d). Second, the vrot distribution of primaries lacks a significant population of stars spinning faster than 300 kms, while such a population is clearly present in the single-star sample. The vrot distribution of binaries with amplitudes of radial velocity variation in the range of 20 to 200~kms (mostly binaries with $P_mathrm{orb} sim 10-1000$,d and/or with $q < 0.5$) is similar to that of single O stars below $vrot lesssim 170$~kms. Our results are compatible with the assumption that binary components formed with the same spin distribution as single stars, and that this distribution contains few or no fast-spinning stars. The higher average spin rate of stars in short-period binaries may either be explained by spin-up through tides in such tight binary systems, or by spin-down of a fraction of the presumed-single stars and long-period binaries through magnetic braking (or by a combination of both mechanisms). Most primaries and secondaries of SB2 systems with $P_mathrm{orb} lesssim 10,$d appear to have similar rotational velocities. This is in agreement with tidal locking in close binaries where the components have similar radii. The lack of very rapidly spinning stars among binary systems supports the idea that most stars with $vrot gtrsim 300$~kms in the single-star sample are actually spun-up post-binary interaction products. Finally, the overall similarities (low-velocity peak and intermediate-velocity shoulder) of the spin distribution of binary and single stars argue for a massive star formation process in which the initial spin is set independently of whether stars are formed as single stars or as components of a binary system.

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Comments: None

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A Coordinated X-ray and Optical Campaign of the Nearest Massive Eclipsing Binary, $delta$ Orionis Aa: III. Analysis of Optical Photometric MOST and Spectroscopic (Ground Based) Variations

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Tabetha Holealtaffilmark{18},
Richard Ignacealtaffilmark{18},
Rosina Ipingaltaffilmark{3},
Jennifer Laueraltaffilmark{13},
Maurice Leuteneggeraltaffilmark{8},
Jamie Lomaxaltaffilmark{19},
Joy Nicholsaltaffilmark{13},
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Stan Owockialtaffilmark{20},
Andy Pollockaltaffilmark{21},
Christopher M. P. Russellaltaffilmark{22,23},
Wayne Waldronaltaffilmark{24},
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We report on both high-precision photometry from the textit{MOST} space telescope and ground-based spectroscopy of the triple system $delta$ Ori A consisting of a binary O9.5II+early-B (Aa1 and Aa2) with $P=$ 5.7d, and a more distant tertiary (O9 IV $P >400$ yrs). This data was collected in concert with X-ray spectroscopy from the Chandra X-ray Observatory. Thanks to continuous coverage for 3 weeks, the textit{MOST} light curve reveals clear eclipses between Aa1 and Aa2 for the first time in non-phased data. From the spectroscopy we have a well constrained radial velocity curve of Aa1. While we are unable to recover radial velocity variations of the secondary star, we are able to constrain several fundamental parameters of this system and determine an approximate mass of the primary using apsidal motion. We also detected second order modulations at 12 separate frequencies with spacings indicative of tidally influenced oscillations. These spacings have never been seen in a massive binary, making this system one of only a handful of such binaries which show evidence for tidally induced pulsations.

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Weblink:

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A Coordinated X-ray and Optical Campaign on the Nearest Massive Eclipsing Binary, Delta Ori Aa: I. Overview of the X-ray Spectrum

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We present an overview of four deep phase-constrained Chandra HETGS X-ray observations of Delta Ori A. Delta Ori A is actually a triple system which includes the nearest massive eclipsing spectroscopic binary, Delta Ori Aa, the only such object that can be observed with little phase-smearing with the Chandra gratings. Since the fainter star, Delta Ori Aa2, has a much lower X-ray luminosity than the brighter primary (Delta Ori Aa1), Delta Ori Aa provides a unique system with which to test the spatial distribution of the X-ray emitting gas around Delta Ori Aa1 via occultation by the photosphere of, and wind cavity around, the X-ray dark secondary. Here we discuss the X-ray spectrum and X-ray line profiles for the combined observation, having an exposure time of nearly 500 ks and covering nearly the entire binary orbit. The companion papers discuss the X-ray variability seen in the Chandra spectra, present new space-based photometry and ground-based radial velocities obtained simultaneous with the X-ray data to better constrain the system parameters, and model the effects of X-rays on the optical and UV spectra. We find that the X-ray emission is dominated by embedded wind shock emission from star Aa1, with little contribution from the tertiary star Ab or the shocked gas produced by the collision of the wind of Aa1 against the surface of Aa2. We find a similar temperature distribution to previous X-ray spectrum analyses. We also show that the line half-widths are about 0.3-0.5 times the terminal velocity of the wind of star Aa1. We find a strong anti-correlation between line widths and the line excitation energy, which suggests that longer-wavelength, lower-temperature lines form farther out in the wind. Our analysis also indicates that the ratio of the intensities of the strong and weak lines of Fe XVII and Ne X are inconsistent with model predictions, which may be an effect of resonance scattering.

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II. X-ray Variability, Nichols et al., 2015, ApJ, in press (arXiv:1507.04972)

III. Analysis of Optical Photometric MOST and Spectroscopic (Ground Based) Variations, Pablo et al., 2015, ApJ, in press (arXiv:1504.08002)

IV. A multiwavelength, non-LTE spectroscopic analysis, Shenar et al,, 2015, ApJ, in press (arXiv:1503.03476)

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A Coordinated X-ray and Optical Campaign of the Nearby Massive Binary Delta Orionis Aa: II. X-ray Variability

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We present time-resolved and phase-resolved variability studies of an extensive X-ray high-resolution spectral dataset of the Delta Ori Aa binary system. The four observations, obtained with Chandra ACIS HETGS, have a total exposure time of $\approx$479 ks and provide nearly complete binary phase coverage. Variability of the total X-ray flux in the range 5-25 Ang. is confirmed, with maximum amplitude of about $\pm$15% within a single $\approx$125 ks observation. Periods of 4.76d and 2.04d are found in the total X-ray flux, as well as an apparent overall increase in flux level throughout the 9-day observational campaign. Using 40 ks contiguous spectra derived from the original observations, we investigate variability of emission line parameters and ratios. Several emission lines are shown to be variable, including S, Si, and Ne. For the first time,variations of the X-ray emission line widths as a function of the binary phase are found in a binary system, with the smallest widths at phase 0.0 when the secondary Delta Ori Aa2 is at inferior conjunction. Using 3D hydrodynamic modeling of the interacting winds, we relate the emission line width variability to the presence of a wind cavity created by a wind-wind collision, which is effectively void of embedded wind shocks and is carved out of the X-ray-producing primary wind, thus producing phase locked X-ray variability.

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X-ray emission from the giant magnetosphere of the magnetic O-type star NGC 1624-2

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We observed NGC 1624-2, the O-type star with the largest known magnetic field Bp~20 kG), in X-rays with the ACIS-S camera onboard the Chandra X-ray Observatory. Our two observations were obtained at the minimum and maximum of the periodic Halpha emission cycle, corresponding to the rotational phases where the magnetic field is the closest to equator-on and pole-on, respectively. With these observations, we aim to characterise the star's magnetosphere via the X-ray emission produced by magnetically confined wind shocks. Our main findings are:

(i) The observed spectrum of NGC 1624-2 is hard, similar to the magnetic O-type star Theta 1 Ori C, with only a few photons detected below 0.8 keV. The emergent X-ray flux is 30% lower at the Halpha minimum phase.

(ii) Our modelling indicated that this seemingly hard spectrum is in fact a consequence of relatively soft intrinsic emission, similar to other magnetic Of?p stars, combined with a large amount of local absorption (~1-3 x 10^22 cm^-2). This combination is necessary to reproduce both the prominent Mg and Si spectral features, and the lack of flux at low energies. NGC 1624-2 is intrinsically luminous in X-rays (log LX emission ~ 33.4) but 70-95% of the X-ray emission produced by magnetically confined wind shocks is absorbed before it escapes the magnetosphere (log LX ISM corrected ~ 32.5).

(iii) The high X-ray luminosity, its variation with stellar rotation, and its large attenuation are all consistent with a large dynamical magnetosphere with magnetically confined wind shocks.

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Effect of scattering on the transonic solution topology and intrinsic variability of line-driven stellar winds

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For line-driven winds from hot, luminous OB stars, we examine the subtle but important role of diffuse, scattered radiation in determining both the topology of steady-state solutions and intrinsic variability in the transonic wind base. We use a smooth source function formalism to obtain nonlocal, integral expressions for the direct and diffuse components of the line-force that account for deviations from the usual localized, Sobolev forms. As the scattering source function is reduced, we find the solution topology in the transonic region transitions from X-type, with a unique wind solution, to a nodal type, characterized by a degenerate family of solutions.

Specifically, in the idealized case of an optically thin source function and a uniformly bright stellar disk, the unique X-type solution proves to be a stable attractor to which time-dependent numerical radiation-hydrodynamical simulations relax. But in models where the scattering strength is only modestly reduced, the topology instead turns nodal, with the associated solution degeneracy now manifest by intrinsic structure and variability that persist down to the photospheric wind base. This highlights the potentially crucial role of diffuse radiation for the dynamics and variability of line driven winds, and seriously challenges the use of Sobolev theory in the transonic wind region. Since such Sobolev-based models are commonly used in broad applications like stellar evolution and feedback, this prompts development of new wind models, not only for further quantifying the intrinsic variability found here, but also for computing new theoretical predictions of global properties like velocity laws and mass-loss rates.

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Fe xxv line profiles in colliding wind binaries

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Strong wind-wind collisions in massive binaries generate a very hot plasma that frequently produces a moderately strong iron line. The morphology of this line depends upon the properties of the wind interaction zone and its orientation with respect to the line of sight. As the binary components revolve around their common centre of mass, the line profiles are thus expected to vary. With the advent of the

next generation of X-ray observatories (Astro-H, Athena) that will offer high-resolution spectroscopy above 6 keV, it will become possible to exploit these changes as the most sensitive probe of the inner parts of the colliding wind interaction. Using a simple prescription of the wind-wind interaction in an early-type binary, we have generated synthetic line profiles for a number of configurations and orbital phases. These profiles can help constrain the properties of the stellar winds in such binary systems.

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Massive star evolution in close binaries:conditions for homogeneous chemical evolution

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We investigate the impact of tidal interactions, before any mass transfer, on various properties of the stellar models. We study the conditions for obtaining homogeneous evolution triggered by tidal interactions, and for avoiding any Roche lobe overflow during the Main-Sequence phase. By homogeneous evolution, we mean stars evolving with a nearly uniform chemical composition from the center to the surface. We consider the case of rotating stars computed with a strong coupling mediated by an interior magnetic field. Models with initial masses between 15 and 60 M$_\odot$, for metallicities between 0.002 and 0.014, with initial rotation equal to 30\% and 66\% the critical rotation on the ZAMS are computed for single stars and for stars in close binary systems. Close binary systems with initial orbital periods equal to 1.4, 1.6 and 1.8 days and a mass ratio equal to 3/2 are considered. In models without any tidal interaction (single stars and wide binaries), homogeneous evolution in solid body rotating models is obtained when two conditions are realized: the initial rotation must be high enough, the loss of angular momentum by stellar winds should be modest. This last point favors metal-poor fast rotating stars. In models with tidal interactions, homogeneous evolution is obtained when rotation imposed by synchronization is high enough (typically a time-averaged surface velocities during the Main-Sequence phase above 250 km s^{-1}), whatever the mass losses. We give plots indicating for which masses of the primary and for which initial periods, the conditions for the homogenous evolution and for the avoidance of the Roche lobe overflow are met, this for different initial metallicities and rotations. In close binaries, mixing is stronger at higher than at lower metallicities. Homogeneous evolution is thus favored at higher metallicities. Roche lobe overflow avoidance is favored at lower metallicities due to the fact that stars with less metals remain more compact. We study also the impact of different processes for the angular momentum transport on the surface abundances and velocities in single and close binaries. In models where strong internal coupling is assumed, strong surface enrichments are always associated to high surface velocities in binary or single star models. In contrast, models computed with mild coupling may produce strong surface enrichments associated to low surface velocities. This observable difference can be used to probe different models for the transport of the angular momentum in stars. Homogeneous evolution is more easily obtained in models (with or without tidal interactions) with solid body rotation.

Close binary models may be of interest for explaining homogeneous massive stars, fast rotating Wolf-Rayet stars, and progenitors of long soft gamma ray bursts, even at high metallicities.

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Abstracts of 3 conference proceedings

Finding Wolf-Rayet Stars in the Local Group

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We summarize past and current surveys for Wolf-Rayet stars among the Local Group galaxies, emphasizing both the how and the why. Such studies are invaluable for helping us learn about massive star evolution, and for providing sensitive tests of the stellar evolution models. But for such surveys to be useful, the completeness limits must be well understood. We illustrate that point in this review by following the ``evolution" of the observed WC/WN ratio in nearby galaxies. We end by examining our new survey for WR stars in the Magellanic Clouds, which has revealed a new type of WN star, never before seen.

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Status: Conference proceedings

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The Discovery and Physical Parameterization of a New Type of Wolf-Rayet Star

K. F. Neugent (1), P. Massey (1), D. J. Hillier (2), and N. I. Morrell (3)

(1) Lowell Observatory, (2) University of Pittsburgh, (3) Las Campanas Observatory

As part of our ongoing Wolf-Rayet (WR) Magellanic Cloud survey, we have discovered 13 new WRs. However, the most exciting outcome of our survey is not the number of new WRs, but their unique characteristics. Eight of our discoveries appear to belong to an entirely new class of WRs. While one might naively classify these stars as WN3+O3V binaries, such a pairing is unlikely. Preliminary CMFGEN modeling suggests physical parameters similar to early-type WNs in the Large Magellanic Cloud except with mass-loss rates three to five times lower and slightly higher temperatures. The evolution status of these stars remains an open question.

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Status: Conference proceedings

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The Importance of Wolf-Rayet Ionization and Feedback on Super Star Cluster Evolution

Kimberly R. Sokal (1), Kelsey E. Johnson (1), Philip Massey (2), Remy Indebetouw (1,3)

1 - University of Virginia, 2 - Lowell Observatory, 3 - NRAO

The feedback from massive stars is important to super star cluster (SSC) evolution and the timescales on which it occurs. SSCs form embedded in thick material, and eventually, the cluster is cleared out and revealed at optical wavelengths -- however, this transition is not well understood. We are investigating this critical SSC evolutionary transition with a multi-wavelength observational campaign. Although previously thought to appear after the cluster has fully removed embedding natal material, we have found that SSCs may host large populations of Wolf-Rayet stars. These evolved stars provide ionization and mechanical feedback that we hypothesize is the tipping point in the combined feedback processes that drive a SSC to emerge. Utilizing optical spectra obtained with the 4m Mayall Telescope at Kitt Peak National Observatory and the 6.5m MMT, we have compiled a sample of embedded SSCs that are likely undergoing this short-lived evolutionary phase and in which we confirm the presence of Wolf-Rayet stars. Early results suggest that WRs may accelerate the cluster emergence.

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Status: Conference proceedings

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JOBS

Postdoctoral Fellow: Massive stars and binaries

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Applications are invited for a postdoctoral fellow at the University of Michigan to work with Prof. Sally Oey on topics related to massive star populations. This may include massive binaries, runaway stars, or Oe/Be stars. The successful candidate will have access to the University of Michigan telescope facilities, including the twin 6.5-m Magellan Telescopes at Las Campanas, the MDM 2.4-m and 1.3-m telescopes at Kitt Peak, and the Swift X-ray satellite. The department has a vibrant environment with several journal clubs and discussion groups. This position is initially available for one year, with likely extension to three years, pending satisfactory performance. The start date is flexible, to begin as soon as possible. The ideal candidate will have experience with multi-object spectroscopic data reduction and analysis for hot stars and/or analysis of binary systems.

To apply, please submit a CV, statement of research interests, and contact details for three references to msoey@umich.edu. Applications should be in PDF format. Please also include your available start date. The position will remain open until filled, but applications received by 30 September 2015 will receive first consideration. The University of Michigan is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

Attention/Comments:

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Deadline: 30 September 2015

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MEETINGS

IAUS 329: The lives and death-throes of massive stars

November 28 to December 2, 2016

Venue: Auckland, New Zealand

Topics

- new results from large-scale surveys at different wavelengths and techniques for massive stars and supernovae
- new observational techniques and instrumentation for massive stars and supernovae
- the link between massive stars and their deaths (core-collapse and other SNe)
- short-lived phases of massive stars (LBVs, WRs and RSGs) and their characteristics as supernova progenitors
- constraints on the nucleosynthesis production in supernovae and the production of dust
- explosion mechanisms of supernovae and the parameters required for a successful explosion
- well established facts and open problems in our knowledge of massive stars
- challenges to present theoretical models: 2D and 3D models of interior and atmospheres
- massive stars as astrophysical tools: tracing the Milky Way and other galaxies structure; limits to our interpretation of the high-z Universe

Dear colleagues,

Research on Massive Stars is undergoing a period of rapid progress. While these stars are relatively few in number they are the main driver of chemical and dynamical evolution in galaxies via their stellar winds and explosive deaths in core-collapse supernovae. Our understanding of massive stars is going through a remarkable time of change with long held convictions being shown to be incomplete. This evidence arises from new research concerning the formation and evolution of massive stars and linking this to their deaths in core-collapse supernovae. Now is a fortuitous time to make significant advances in massive star research. We propose a meeting with the central rationale to bring together the two communities that study massive stars and their supernovae.

The impact of massive stars is widely recognized in many areas. They are often used as tools to interpret the conditions and processes arising in different environments (studies of Galactic structure, chemical and dynamical feedback, population synthesis, Starbursts, high-z galaxies and cosmic reionization). In parallel, the development of new instrumentation, analysis techniques and dedicated surveys across all possible wavelengths have delivered large amounts of exquisite new data. This data is now providing a harsh test for the current state-of-the-art theoretical calculations of massive star birth, evolution and death.

We are beginning to gain some measure of success understanding how complex phenomena such as magnetic fields, pulsations, rotation, mergers and multiplicity act within massive stars. This enables us to revolutionize our understanding of short-lived and enigmatic phases such as seen in Wolf-Rayet stars, Red Supergiants, the Luminous Blue Variables and B-Supergiants. But at the same time, mysteries persist surrounding these phases and the supernovae produced by these stars. For example there is growing evidence that all these stars, except the Wolf-Rayet stars, give rise to supernovae.

Finally, while we know individual stars are important, the impact of massive star populations via their evolution and death, including the influence of X-ray and gamma-ray binaries, is of high interest to those studying the high-z Universe. Locating the source of photons needed to reionize the early Universe remains unsolved. Uncertainties in our understanding of massive star populations impacts our interpretation of galaxies at the edge of the observable Universe and how the Universe became transparent.

In view of recent developments and the significant impact massive stars have in the broader community, a new IAU Symposium in late 2016 was proposed and supported by the IAU. 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.

In particular we plan to address the following topics:
- new results from large-scale surveys at different wavelengths and techniques for massive stars (e.g. influence of rotation, multiplicity fractions, asteroseismology, magnetic fields, high-energy detections, polarization, interferometry) and supernovae (e.g. relative rates of different types, peculiar new classes of

events, most energetic and least luminous events)
- new observational techniques and instrumentation for massive stars (e.g. interferometry, astereoseismology) and supernovae (e.g. polarization and light echos)
- the link between massive stars and their deaths (core-collapse and other SNe and GRBs; progenitors of black holes, neutron stars and magnetars)
- short-lived phases of massive stars (LBVs, WRs and RSGs) and their characteristics as supernova progenitors
- constraints on the nucleosynthesis production in supernovae and the production of dust
- explosion mechanisms of supernovae and the parameters required for a successful explosion
- well established facts and open problems in our knowledge of massive stars, particularly in the so-thought well understood phases
- challenges to present theoretical models of interior and atmospheres; connecting interior and atmospheres; wind structure; episodic mass-loss mechanisms; binaries in interaction; gamma-ray production
- massive stars as astrophysical tools: tracing galaxies' structure; tracers of star formation; feedback from massive stars; population synthesis; limits to our interpretation of the high-z Universe; cosmic reionization; first stars and galaxies.

Dr J.J. Eldridge (University of Auckland), Prof Margaret Hanson (University of Cincinnati) and Dr Artemio Herrero (Instituto de Astrofisica) will act as co-chairs of the SOC. The MSWG will assist in the preparation of the final proposal and will pay special attention to guarantee scientific, geographical and gender diversity balance in the SOC following the IAU rules for universality in science. This aim for diversity and balance will be carried through to selection of invited speakers and session chairs. We will also consider the particular importance to early career astronomers of presenting their work at this significant large scale meeting.

The massive star community has traditionally held IAU Symposia with a frequency of 4-5 years (Argentina, 1971; Canada, 1978; Mexico, 1981; Greece, 1985; Indonesia, 1990; Italy, 1994; Mexico, 1998; Spain, 2002; USA, 2007). More recently, a last meeting was held in Greece in June 2013, without IAU sponsorship, but with great success (225 participants from 27 countries). Seeking for a long-term geographical balance, the IAU MSWG selected New Zealand as location for this meeting among a total of seven proposals. We hope that the selection of this venue will allow greater participation by countries in the Asia and Pacific area.

Weblink: http://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/en/meetings/getMeetings.html?number=4716

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