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THE MASSIVE STAR NEWSLETTER

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Accepted Papers

A Rigid-Field Hydrodynamics approach to modeling the magnetospheres of massive stars

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We introduce a new Rigid-Field Hydrodynamics approach to modeling the magnetospheres of massive stars in the limit of very-strong magnetic fields. Treating the field lines as effectively rigid, we develop hydrodynamical equations describing the 1-dimensional flow along each, subject to pressure, radiative, gravitational, and centrifugal forces. We solve these equations numerically for a large ensemble of field lines, to build up a 3-dimensional time-dependent simulation of a model star with parameters similar to the archetypal Bp star sigma Ori E. Since the flow along each field line can be solved for independently of other field lines, the computational cost of this approach is a fraction of an equivalent magnetohydrodynamical treatment.

The simulations confirm many of the predictions of previous analytical and numerical studies. Collisions between wind streams from opposing magnetic hemispheres lead to strong shock heating. The post-shock plasma cools initially via X-ray emission, and eventually accumulates into a warped, rigidly rotating disk defined by the locus of minima of the effective (gravitational plus centrifugal) potential. But a number of novel results also emerge. For field lines extending far from the star, the rapid area

divergence enhances the radiative acceleration of the wind, resulting in high shock velocities (up to $\sim$3,000 km/s) and hard X-rays. Moreover, the release of centrifugal potential energy continues to heat the wind plasma after the shocks, up to temperatures around twice those achieved at the shocks themselves. Finally, in some circumstances the cool plasma in the accumulating disk can oscillate about its equilibrium position, possibly due to radiative cooling instabilities in the adjacent post-shock regions.

Reference: MNRAS, in press

On the web at: `http://arxiv.org/pdf/0709.0694`

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

A Survey of Local Group Galaxies Currently Forming Stars: III. A Search for Luminous Blue Variables and Other Halpha Emission-Lined Stars

Philip Massey (1), Reagin T. McNeill (1,2), K. A. G. Olsen (3), Paul W. Hodge (4), Cynthia Blaha (5), George H. Jacoby (6), R. C. Smith (3), and Shay B. Strong (7)

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We describe a search for Halpha emission-lined stars in M31, M33, and seven dwarfs in or near the Local Group (IC 10, NGC 6822, WLM, Sextans B, Sextans A, Pegasus and the Phoenix dwarf) using interference filter imaging with the KPNO and CTIO 4-m telescope and Mosaic cameras. The survey is aimed primarily at identifying new Luminous Blue Variables (LBVs) from their spectroscopic similarity to known LBVs, avoiding the bias towards photometric variability, which may require centuries to manifest itself if LBVs go through long quiescent periods. Followup spectroscopy with WIYN confirms that our survey detected a wealth of stars whose spectra are similar to the known LBVs. We "classify" the spectra of known LBVs, and compare these to the spectra of the new LBV candidates. We demonstrate spectacular spectral variability for several of the new LBV candidates, such as AM2, previously classified as a Wolf-Rayet star, which now shows Fe I, Fe II and Balmer emission lines but neither the N III 4634,42 nor He II 4686 emission that it did in 1982. Profound spectral changes are also noted for other suspected and known LBVs. Several of the LBV candidates also show >0.5 mag changes in V over the past 10-20 years. The number of known or suspected LBVs is now 24 in M31, 37 in M33, 1 in NGC 6822, and 3 in IC 10. We estimate that the total number of LBVs in M31 and M33 may be several hundred, in contrast to the 8 known historically through large-scale photometric variability. This has significant implications for the time scale of the LBV phase. We also identify a few new WRs and peculiar emission-lined objects.

Reference: Astronomical Journal, in press

On the web at: `http://www.lowell.edu/users/massey/has.pdf.gz`

Preprints from: `Phil.Massey@lowell.edu`

Colliding Stellar Wind Models with Nonequilibrium Ionization: X-rays from WR 147

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The effects of nonequilibrium ionization are explicitly taken into account in a numerical model which describes colliding stellar winds (CSW) in massive binary sytems. This new model is used to analyze the most recent X-ray spectra of the WR+OB binary system WR 147. The basic result is that it can adequately reproduce the observed X-ray emission (spectral shape, observed flux) but some adjustment in the stellar wind parameters is required. Namely, (i) the stellar wind velocities must be higher by a factor of 1.4 - 1.6; (ii) the mass loss must be reduced by a factor of ~ 2. The reduction factor for the mass loss is well within the uncertainties for this parameter in massive stars, but given the fact that the orbital parameters (e.g., inclination angle and eccentricity) are not well constrained for WR 147, even smaller corrections to the mass loss might be sufficient. Only CSW models with nonequilibrium ionization and equal (or nearly equal) electron and ion postshock temperature are successful. Therefore, the analysis of the X-ray spectra of WR 147 provides evidence that the CSW shocks in this object must be collisionless.

Reference: MNRAS

On the web at: `http://arxiv.org/abs/0709.1686`

Preprints from: `zhekovs@colorado.edu`

The RMS Survey: Mid-Infrared Observations of Candidate Massive YSOs in the Southern Hemisphere

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Context: The Red MSX Source (RMS) survey is an ongoing effort to return a large, well-selected sample of massive young stellar objects (MYSOs) within our Galaxy. 2000 candidates have been colour-selected from the Mid-course Space Experiment (MSX) point source catalogue (PSC). A series of ground-based follow-up observations are being undertaken in order to remove contaminant objects (ultra-compact HII (UCHII) regions, planetary nebulae (PN), evolved stars), and to begin characterising these MYSOs.

Aims: As a part of these follow-up observations, high resolution (∼1”) mid-IR imaging aids the identification of contaminant objects which are resolved (UCHII regions, PN) as opposed to those which are unresolved (YSOs, evolved stars) as well as identifying YSOs near UCHII regions and other multiple sources.

Method: We present 10.4 micron imaging observations for 346 candidate MYSOs in the RMS survey in the Southern Hemisphere, primarily outside the region covered by the GLIMPSE Spitzer Legacy Survey. These were obtained using TIMMI2 on the ESO 3.6m telescope in La Silla, Chile. Our photometric accuracy is of order 0.05Jy, and our astrometric accuracy is 0.8”, which is an improvement over the nominal 2” accuracy of the MSX PSC.

Results: Point sources are detected in 64% of our observations, which are expected to be either YSOs or evolved stars. 24% contain only sources of extended emission, which are likely to be either UCHII regions or, in a few cases, PN. This is confirmed by comparison with radio continuum observations. We find that, as expected for a dusty HII region, the strength of 10.4 micron and radio continuum emission is related. The remaining targets (12%) result in non-detections. While for 63% of our targets we detect only one mid-infrared source, 25% show multiple sources. In these cases, our observations will allow the apportioning of the flux from larger beam measurements between the different sources. Within these multiple source targets, we find some point sources on or near UCHII regions. Our improved astrometric information will allow more accurate targeting of spectroscopy, which will be used to identify unresolved sources in cases where it is not clear whether they are YSOs or evolved stars.

Reference: Accepted by Astronomy and Astrophysics

Comments: Preprint available at http://arxiv.org/abs/0709.2040

Preprints from: jcm@ast.leeds.ac.uk

Non-thermal emission processes in massive binaries

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In this paper, I present a general discussion of several astrophysical processes likely to play a role in the production of non-thermal emission in massive stars, with emphasis on massive binaries. Even though the discussion will start in the radio domain where the non-thermal emission was first detected, the census of physical processes involved in the non-thermal emission from massive stars shows that many spectral domains are concerned, from the radio to the very high energies. First, the theoretical aspects of the non-thermal emission from early-type stars will be addressed. The main topics that will be discussed are respectively the physics of individual stellar winds and their interaction in binary systems, the acceleration of relativistic electrons, the magnetic field of massive stars, and finally the non-thermal emission processes relevant to the case of massive stars. Second, this general qualitative discussion will be followed by a more quantitative one, devoted to the most probable scenario where non-thermal radio emitters are massive binaries. I will show how several stellar, wind and orbital parameters can be combined in order to make some semi-quantitative predictions on the high-energy counterpart to the non-thermal emission detected in the radio domain. These theoretical considerations will be followed by a census of results obtained so far, and related to this topic. These results concern the radio, the visible, the X-ray and the gamma-ray domains. Prospects for the very high energy & #947;-ray emission from massive stars will also be addressed. Two particularly interesting examples one O-type and one Wolf-Rayet binary will be considered in details. Finally, strategies for future developments in this field will be discussed.

Reference: Astronomy & Astrophysics Review, in press

Comments: The full paper is available on www.springerlink.com (Online First)

On the web at: http://adsabs.harvard.edu/doi/10.1007/s00159-007-0005-2

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

The B and Be Star Population of NGC 3766

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1-Lehigh University; 2-California Institute of Technology; 3-Georgia State University; 4-Vanderbilt University; 5-University of Delaware

We present multiple epochs of H$alpha$ spectroscopy for 47 members of the open cluster NGC 3766 to investigate the long term variability of its Be stars. Sixteen of the stars in this sample are Be stars, including one new discovery. Of these, we observe an unprecedented 11 Be stars that undergo disk appearances and/or near disappearances in our H$alpha$ spectra, making this the most variable population of Be stars known to date. NGC 3766 is therefore an excellent location to study the formation mechanism of Be star disks. From blue optical spectra of 38 cluster members and existing Str"omgren photometry of the cluster, we also measure rotational velocities, effective temperatures, and polar surface gravities to investigate the physical and evolutionary factors that may contribute to the Be phenomenon. Our analysis also provides improvements to the reddening and distance of NGC 3766, and we find $E(B-V) = 0.22pm0.03$ and $(V - M_{rmV})_0 = 11.6pm0.2$, respectively. The Be stars are not associated with a particular stage of main-sequence evolution, but they are a population of rapidly rotating stars with a velocity distribution generally consistent with rotation at $70-80\%$ of the critical velocity, although systematic effects probably underestimate the true rotational velocities so that the rotation is much closer to critical. Our measurements of the changing disk sizes are consistent with the idea that transitory, nonradial pulsations contribute to the formation of these highly variable disks.

Reference: to appear in the Astrophysical Journal

On the web at: `astro-ph/0710.0137`

Preprints from: `mcswain@lehigh.edu`

X-ray Emission from Magnetically Torqued Disks of Oe/Be Stars

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We focus attention on the Oe/Be stars to test the concept that the disks of these stars form by magnetic channeling of wind material toward the equator. Calculations are made of the X-rays expected from the Magnetically Torqued Disk (MTD) model for Be stars discussed by Cassinelli et al. (2002), by Maheswaran (2003), and by Brown et al. (2004). The dominant parameters in the model are the $beta$ value of the velocity law, the rotation rate of the star, S_o, and the ratio of the magnetic field energy density to the disk gravitational energy density, $gamma$.

The model predictions are compared with the $ROSAT$ observations obtained for an O9.5 star $zeta$ Oph from Berghofer et al. (1996) and for 7 Be stars from Cohen et al. (1997). Extra considerations are also given here to the well studied Oe star $zeta$ Oph for which we have $Chandra$ observations of the X-ray line profiles of the triad of He-like lines from the ion Mg XI.

Reference: ApJ in press.

On the web at: `http://arxiv.org/abs/astro-ph/0710.2633`

Preprints from: `qkli@bnu.edu.cn`

Modeling the line variations from the wind-wind shock emissions of WR30a

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The study of Wolf-Rayet stars plays an important role in evolutionary theories of massive stars. Among these objects, $\sim 20\%$ are known to be in binary systems and can therefore be used for the mass determination of these stars. Most of these systems are not spatially resolved and spectral lines can be used to constrain the orbital parameters. However, part of the emission may originate in the interaction zone between the stellar winds, modifying the line profiles and thus challenging us to use different models to interpret them. In this work, we analyzed the HeII4686AA + CIV4658AA blended lines of WR30a (WO4+O5) assuming that part of the emission originate in the wind-wind interaction zone. In fact, this line presents a quiescent base profile, attributed to the WO wind, and a superposed excess, which varies with the orbital phase along the 4.6 day period. Under these assumptions, we were able to fit the excess spectral line profile and central velocity for all phases, except for the longest wavelengths, where a spectral line with constant velocity seems to be present. The fit parameters provide the eccentricity and inclination of the binary orbit, from which it is possible to constrain the stellar masses.

Reference: accepted for publication in the MNRAS

On the web at: `http://arxiv.org/abs/0710.0662`

Preprints from: `diego.goncalves@unicsul.br`

Proceedings

The impact of reduced mass loss rates on the evolution of massive stars

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Mass loss is a very important aspect of the life of massive stars. After briefly reviewing its importance, we discuss the impact of the recently proposed downward revision of mass loss rates due to clumping (difficulty to form Wolf-Rayet stars and production of critically rotating stars). Although a small reduction might be allowed, large reduction factors around ten are disfavoured. We then discuss the possibility of significant mass loss at very low metallicity due to stars reaching break-up velocities and especially due to the metal enrichment of the surface of the star via rotational and convective mixing. This significant mass loss may help the first very massive stars avoid the fate of pair-creation

supernova, the chemical signature of which is not observed in extremely metal poor stars. The chemical composition of the very low metallicity winds is very similar to that of the most metal poor star known to date, HE1327-2326 and offer an interesting explanation for the origin of the metals in this star. We also discuss the importance of mass loss in the context of long and soft gamma-ray bursts and pair-creation supernovae. Finally, we would like to stress that mass loss in cooler parts of the HR-diagram (luminous blue variable and yellow and red supergiant stages) are much more uncertain than in the hot part. More work needs to be done in these areas to better constrain the evolution of the most massive stars.

Reference: proceedings for a review talk at the International Workshop on "CLUMPING in Hot-Star Winds", 18. - 22. June 2007, Potsdam, Germany. To be published electronically by the University of Potsdam (Universitaets-Verlag), Editors: Wolf-Rainer Hamann, Achim Feldmeier and Lidia Oskinova

Comments: 5 pages, 2 figures

On the web at: `http://arxiv.org/abs/0709.0392`

Preprints from: `r.hirschi@epsam.keele.ac.uk`

Techniques for simulating radiative transfer through porous media

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In this contribution, I discuss some basic techniques that can be used to simulate radiative transfer through porous media. As specific examples, I consider scattering transfer through a clumped slab, and X-ray emission line formation in a clumped wind.

Reference: To appear in proceedings of "Clumping in Hot Star Winds" conference (Potsdam, Germany, June 2007)

On the web at: `http://arxiv.org/pdf/0709.0860`

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

The coupling between pulsation and mass loss in massive stars

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To what extent can pulsational instabilities resolve the mass-loss problem of massive stars? How important is pulsation in structuring and modulating the winds of these stars? What role does pulsation play in redistributing angular momentum in massive stars? Although I cannot offer answers to these questions, I hope at the very least to explain how they come to be asked.

Reference: To appear in proceedings of "Unsolved Problems in Stellar Physics" conference (Cambridge, UK, July 2007)

On the web at: `http://arxiv.org/pdf/0709.0761`

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

The investigation of particle acceleration in colliding-wind massive binaries with SIMBOL-X.

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An increasing number of early-type (O and Wolf-Rayet) colliding wind binaries (CWBs) is known to accelerate particles up to relativistic energies. In this context, non-thermal emission processes such as inverse Compton (IC) scattering are expected to produce a high energy spectrum, in addition to the strong thermal emission from the shock-heated plasma. SIMBOL-X will be the ideal observatory to investigate the hard X-ray spectrum (above 10 keV) of these systems, i.e. where it is no longer dominated by the thermal emission. Such observations are strongly needed to constrain the models aimed at understanding the physics of particle acceleration in CWB. Such systems are important laboratories for investigating the underlying physics of particle acceleration at high Mach number shocks, and probe a different region of parameter space than studies of supernova remnants.

Reference: To appear in the proceedings of the workshop "Simbol-X: the hard X-ray universe in focus", held in Bologna, Italy (14-16 May 2007)

On the web at: `http://arxiv.org/abs/0709.1033`

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

Meetings

Super-AGB stars and the fine line between White Dwarf or Supernova

8 February 2008
London (UK)

Royal Astronomical Society Specialist Discussion Meeting

Depending on its initial mass, a star may end as a white dwarf or explode as a supernova. The dividing boundary is however ill-defined, and depends on the treatment of convection and mass loss. Asymptotic Giant Branch (AGB) stars do not ignite carbon and end up as carbon-oxygen white dwarfs. But if mass loss is weak the core may grow to reach the Chandrasekhar mass limit and explode as a thermonuclear supernova. Slightly more massive stars ignite carbon and, like AGB stars, they also undergo thermal pulses. These super-AGB stars may leave an oxygen-neon white dwarf, but their fate is unclear. They will either produce an oxygen-neon white dwarf or explode in an electron capture supernova and produce a neutron star. Red supergiants of initial mass as low as 8 solar masses have now been identified directly as the progenitors of type IIP supernovae. With the Initial Mass Function favouring the low mass end of the supernova progenitors, massive AGB stars contributing to nitrogen enrichment on timescales as short as tens of million years, and both supernovae and AGB stars competing for the title of most prolific dust factory in the early Universe, it is crucial to gain a better understanding of the boundary between massive AGB stars and the progenitors of core-collapse supernovae.

The meeting will start at 10:00 and lasts until 15:30. Besides contributed talks and discussion time, the meeting will be based around three keynote lectures:
"Understood, uncertain and unknown physics of super-AGB stars", Richard Stancliffe, Cambridge University (UK)
"Observational constraints on the most massive white dwarf progenitors", Kurtis Williams, University of Texas (USA)
"Observational constraints on the masses of supernova progenitors", Stephen Smartt, Queen's University Belfast (UK) with an opening speech and closing remarks provided by Alvio Renzini, Universit'a di Padova (Italia).

Please register by 30 November 2007, especially (with a title and abstract) if you want to propose a talk. Ample space is available for posters.

The meeting is free to all Fellows of the RAS, but make sure you bring along your RAS member card! A small entry fee is charged for non-fellows, collected on the door: 15 pounds Sterling (or 5 pounds with a valid student card).

There will be no traditional proceedings, and hence no burden on your time after the meeting. However, we aim to place all electronic contributions (talks, posters, additional material if appropriate) on the web, and will announce this via the AGB Newsletter, Massive Stars Newsletter and arXiv.org. We also plan to write a summary article for publication in the RAS journal "Astronomy & Geophysics" shortly after the meeting, which we hope will also capture the essence of the discussions that took place.

See you in London!

Jacco van Loon (Keele University) and John Eldridge (Cambridge University) on behalf of the UK Working Group on Evolved Stars

Weblink: `http://www.astro.keele.ac.uk/e-stars/ras2008/ras2008.html`

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