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# THE MASSIVE STAR NEWSLETTER

formely known as the hot star newsletter

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# PAPERS

# Abstracts of 15 accepted papers

## An Ultraviolet Spectroscopic Atlas of Local Starbursts and Star-Forming Galaxies: The Legacy of FOS and GHRS

**Claus Leitherer(1), Christy Tremonti(2), Tim Heckman(3), & Daniela Calzetti(4)**

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We present 46 rest-frame ultraviolet (UV) spectra of 28 local starburst and star-forming galaxies which were observed with the Faint Object Spectrograph (FOS) and the Goddard High Resolution Spectrograph (GHRS) of the Hubble Space Telescope (HST) at a spectral resolution of a few 100 km/s. We compare the HST spectra with lower resolution International Ultraviolet Explorer (IUE) spectra of the same galaxies and find systematic differences: the bright star clusters targeted in HST's ~1" apertures provide about 15% of the starburst luminosity traced by IUE's 10" by 20" aperture; they are bluer and have stronger stellar-wind features suggesting that the HST apertures have preferentially been placed on the youngest areas of the burst. In contrast, lines arising from the interstellar medium (ISM) show similar equivalent widths in both the large and small aperture observations, suggesting similar ISM properties from larger to smaller scales. In order to quantify the UV spectral morphology of star-forming galaxies, we created a set of UV line indices similar to the standard optical Lick indices. We discuss the relation between the UV spectral morphology and the properties of the galaxy host. We present our atlas of FOS and GHRS spectra both in print and electronically. The data set is useful as a baseline for comparisons with observations of the rest-frame UV spectra of star-forming galaxies at high redshift.

**Reference:** AJ, in press
Status: Manuscript has been accepted

**Weblink:** http://xxx.lanl.gov/abs/1011.0385

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## A proper description of clumping in hot star winds: the key to obtaining reliable mass-loss rates?

**Jon O. Sundqvist (1), Joachim Puls (1), Achim Feldmeier (2), and Stanley P. Owocki (3)**

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Small-scale inhomogeneities, or `clumping', in the winds of hot, massive stars are conventionally included in spectral analyses by assuming optically thin clumps. To reconcile investigations of different diagnostics using this microclumping technique, very low mass-loss rates must be invoked for O stars. Recently it has been suggested that by using the microclumping approximation one may actually drastically underestimate the mass-loss rates. Here we demonstrate this, present a new, improved description of clumpy winds, and show how corresponding models, in a combined UV and optical analysis, can alleviate discrepancies between previously derived rates and those predicted by the line-driven wind theory.
Furthermore, we show that the structures obtained in time-dependent, radiation-hydrodynamic simulations of the intrinsic line-driven instability of such winds, which are the basis to our current understanding of clumping, in their present-day form seem unable to provide a fully self-consistent, simultaneous fit to both UV and optical lines. The reasons for this are discussed.

**Reference:** 5 pages, 2 figures, to appear in the proceedings of 39th Liege International Astrophysical Colloquium on 'The multi-wavelength view of hot, massive stars', Liege, 12-16 July 2010
Status: Manuscript has been accepted

**Weblink:** http://arxiv.org/abs/1010.3987

**Comments:**

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## Spiralling out of control: 3D hydrodynamical modelling of the colliding winds in Eta Carinae

**E. R. Parkin (1,2,6), J. M. Pittard (2), M. F. Corcoran (3,4), K. Hamaguchi (3,5)**

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Three dimensional (3D) adaptive-mesh refinement (AMR) hydrodynamical simulations of the wind-wind collision between the enigmatic super-massive star etacar and its mysterious companion star are presented which include radiative driving of the stellar winds, gravity, optically-thin radiative cooling, and orbital motion. Simulations with static stars with a periastron passage separation reveal that the preshock companion star's wind speed is sufficiently reduced that radiative cooling in the postshock gas becomes important, permitting the runaway growth of non-linear thin shell (NTSI) instabilities which massively distort the WCR. However, large-scale simulations which include the orbital motion of the stars, show that orbital motion reduces the impact of radiative inhibition, and thus increases the acquired preshock velocities. As such, the postshock gas temperature and cooling time see a commensurate increase, and sufficient gas pressure is preserved to stabilize the WCR against catastrophic instability growth. We then compute synthetic X-ray spectra and lightcurves and find that, compared to previous models, the X-ray spectra agree much better with XMM-Newton observations just prior to periastron. The narrow width of the 2009 X-ray minimum can also be reproduced. However, the models fail to reproduce the extended X-ray mimimum from previous cycles. We conclude that the key to explaining the extended X-ray minimum is the rate of cooling of the companion star's postshock wind. If cooling is rapid then powerful NTSIs will heavily disrupt the WCR. Radiative inhibition of the companion star's preshock wind, albeit with a stronger radiation-wind coupling than explored in this work, could be an effective trigger.

**Reference:** Accepted for publication in ApJ
Status: Manuscript has been accepted

**Weblink:** http://arxiv.org/abs/1011.0778

**Comments:** 25 pages, 20 figures.

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## Numerical heat conduction in hydrodynamical models of colliding hypersonic flows

**E. R. Parkin (1,2) & J. M. Pittard (2)**

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Hydrodynamical models of colliding hypersonic flows are presented which explore the dependence of the resulting dynamics and the characteristics of the derived X-ray emission on numerical conduction and viscosity. For the purpose of our investigation, we present models of colliding flow with plane-parallel and cylindrical divergence. Numerical conduction causes erroneous heating of gas across the contact discontinuity which has implications for the rate at which the gas cools. We find that the dynamics of the shocked gas and the resulting X-ray emission are strongly dependent on the contrast in the density and temperature either side of the contact discontinuity, these effects being strongest where the post-shock gas of one flow behaves quasi-adiabatically while the post-shock gas of the other flow is strongly radiative. Introducing additional numerical viscosity into the simulations has the effect of damping the growth of instabilities, which in some cases act to increase the volume of shocked gas and can re-heat gas via sub-shocks as it flows downstream. The resulting reduction in the surface area between adjacent flows, and therefore in the amount of numerical conduction, leads to a commensurate reduction in spurious X-ray emission, though the dynamics of the collision are compromised.
The simulation resolution also affects the degree of numerical conduction. A finer resolution better resolves the interfaces of high density and temperature contrast, and although numerical conduction still exists the volume of affected gas is considerably reduced. However, since it is not always practical to increase the resolution, it is imperative that the degree of numerical conduction is understood so that inaccurate interpretations can be avoided. This work has implications for the dynamics and emission from astrophysical phenomena which involve high Mach number shocks.

**Reference:** Mon. Not. R. Astron. Soc. 406, 2373–2385 (2010)
Status: Manuscript has been accepted

**Weblink:** http://adsabs.harvard.edu/abs/2010MNRAS.406.2373P

**Comments:** 13 pages, 10 figures

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# Thin shell morphology in the circumstellar medium of massive binaries

**A. J. van Marle$^1$, R. Keppens$^1,2,3$ and Z. Meliani$^1$**

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In massive binaries, the powerful stellar winds of the two stars collide, leading to the formation of shock-dominated environments that can be modelled only in 3D.

We investigate the morphology of the collision front between the stellar winds of binary components in two long-period binary systems, one consisting of a hydrogen rich Wolf-Rayet star (WNL) and an O-star and the other of a Luminous Blue Variable (LBV) and an O-star. Specifically, we follow the development and evolution of instabilities that form in such a shell, if it is sufficiently compressed, due to both the wind interaction and the orbital motion.

We use MPI-AMRVAC to time-integrate the equations of hydrodynamics, combined with optically thin radiative cooling, on an adaptive mesh 3D grid. Using parameters for generic binary systems, we simulate the interaction between the winds of the two stars.

The WNL + O star binary shows a typical example of an adiabatic wind collision.
The resulting shell is thick and smooth, showing no instabilities.
On the other hand, the shell created by the collision of the O star wind with the LBV wind, combined with the orbital motion of the binary components, is susceptible to thin shell instabilities, which create a highly structured morphology.
We identify the nature of the instabilities as both linear and non-linear thin-shell instabilities, with distinct differences between the leading and the trailing parts of the collision front. We also find that for binaries containing a star with a (relatively) slow wind, the global shape of the shell is determined more by the slow wind velocity and the orbital motion of the binary, than the ram pressure balance between the two winds.

The interaction between massive binary winds needs further parametric exploration, to identify the role and dynamical importance of multiple instabilities at the collision front, as shown here for an LBV + O star system.

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Status: Manuscript has been accepted

**Weblink:** http://arxiv.org/abs/1011.1734

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# Gemini GMOS spectroscopy of HeII nebulae in M33

**C.Kehrig (1,2), M.S.Oey (2),P.A.Crowther (3), J.Fogel (2),E.Pellegrini (2), O.Schnurr (1,3), D.**

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We have carried out a narrow-band survey of the Local Group galaxy, M33, in the HeII4686 emission line, to identify HeII nebulae in this galaxy. With spectroscopic follow-up observations, we confirm three of seven candidate objects, including identification of two new HeII nebulae, BCLMP651, HBW673. We also obtain spectra of associated ionizing stars for all the HII regions,identifying two new WN stars. We demonstrate that the ionizing source for the known HeII nebula, MA 1, is consistent with being the early-type WN star MC8 (M33-WR14), by carrying out a combined stellar and nebular analysis of MC8 and MA1. We were unable to identify the helium ionizing sources for HBW673 and BCLMP651, which do not appear to be Wolf-Rayet stars. According to the [OIII]5007/Hbeta vs [NII]6584/Halpha diagnostic diagram, excitation mechanisms apart from hot stellar continuum are needed to account for the nebular emission in HBW673, which appears to have no stellar source at all.

**Reference:** A&A, in press (arXiv:1011.2430)
Status: Manuscript has been accepted

**Weblink:**

**Comments:** The manuscript is accepted for publication in section 4. Extragalactic astronomy of Astronomy and Astrophysics.

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# Massive star models with magnetic braking

**Georges Meynet, Patrick Eggenberger and Andre Maeder**

Geneva Observatory, Geneva University

Magnetic fields at the surface of a few early-type stars have been directly detected. These fields have magnitudes between a few hundred G up to a few kG. In one case, evidence of magnetic braking has been found. We investigate the effects of magnetic braking on the evolution of rotating ($upsilon_{rm ini}$=200 km s$^{-1}$) 10 M$_odot$ stellar models at solar metallicity during the main-sequence (MS) phase. The magnetic braking process is included in our stellar models according to the formalism deduced from 2D MHD simulations of magnetic wind confinement by ud-Doula and co-workers. Various assumptions are made regarding both the magnitude of the magnetic field and of the efficiency of the angular momentum transport mechanisms in the stellar interior. When magnetic braking occurs in models with differential rotation, a strong and rapid mixing is obtained at the surface accompanied by a rapid decrease in the surface velocity. Such a process might account for some MS stars showing strong mixing and low surface velocities. When solid-body rotation is imposed in the interior, the star is slowed down so rapidly that surface enrichments are smaller than in similar models with no magnetic braking. In both kinds of models (differentially or uniformly rotating), magnetic braking due to a field of a few 100 G significantly reduces the angular momentum of the core during the MS phase. This reduction is much greater in solid-body rotating models.

**Reference:** A&A Letter
Status: Manuscript has been accepted

**Weblink:** arXiv

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# Ultraviolet Spectroscopy of Circumnuclear Star Clusters in M83

**Aida Wofford$^1$, Rupali Chandar$^2$, and Claus Leitherer$^1$**

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We analyze archival HST/STIS/FUV-MAMA imaging and spectroscopy of 13 compact star clusters within the circumnuclear starburst region of M83, the closest such example. We compare the observed spectra with semi-empirical models, which are based on an empirical library of Galactic O and B stars observed with IUE, and with theoretical models, which are based on a new theoretical UV library of hot massive stars computed with WM-Basic. The models were generated with Starburst99 for metallicities of Z=0.020 and Z=0.040, and for stellar IMFs with upper mass limits of 10, 30, 50, and 100 M_sol. We estimate the ages and masses of the clusters from the best fit model spectra, and find that the ages derived from the semi-empirical and theoretical models agree within a factor of 1.2 on average. A comparison of the spectroscopic age estimates with values derived from HST/WFC3/UVIS multi-band photometry shows a similar level of agreement for all but one cluster. The clusters have a range of ages from about 3 to 20 Myr, and do not appear to have an age gradient along M83's starburst. Clusters with strong P-Cygni profiles have masses of a few times 104 M_sol, seem to have formed stars more massive than 30 M_sol, and are consistent with a Kroupa IMF from 0.1-100 M_sol. Field regions in the starburst lack P-Cygni profiles and are dominated by B stars.

**Reference:** ApJ accepted
Status: Manuscript has been accepted

**Weblink:** http://arxiv.org/abs/1011.4449

**Comments:**

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# RECENT X-RAY VARIABILITY OF η CARINAE: THE QUICK ROAD TO RECOVERY

**M.~F.~Corcoran[1,2], K.~Hamaguchi[1,3], J.~M.~Pittard[4], C.~M.~P.~Russell[5], S.~P.~Owocki[5], E.~R.~Parkin[6],
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We report continued monitoring of the superluminous binary system Eta Car by the Proportional Counter Array on the Rossi X-ray Timing Observatory (RXTE) through the 2009 X-ray minimum. The RXTE campaign shows that the minimum began on 2009 January 16, consistent with the phasings of the two previous minima, and overall, the temporal behavior of the X-ray emission was similar to that observed by RXTE in the previous two cycles. However, important differences did occur. The 2--10 keV X-ray flux and X-ray hardness decreased in the 2.5-year interval leading up to the 2009 minimum compared to the previous cycle. Most intriguingly, the 2009 X-ray minimum was about one month shorter than either of the previous two minima. During the egress from the 2009 minimum the X-ray hardness increased markedly as it had during egress from the previous two minima, although the maximum X-ray hardness achieved was less than the maximum observed after the two previous recoveries. We suggest that the cycle-to-cycle variations, especially the unexpectedly early recovery from the 2009 X-ray minimum, might have been the result of a decline in Eta Car's wind momentum flux produced by a drop in Eta Car's mass loss rate or wind terminal velocity (or some combination), though if so the change in wind momentum flux required to match the X-ray variation is surprisingly large.

**Reference:** ApJ, 725, 1528-1535
Status: Manuscript has been accepted

**Weblink:** http://iopscience.iop.org/0004-637X/725/2/1528/

**Comments:**

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# Effects of anisotropic winds on massive stars evolution

**Cyril Georgy$^1$, Georges Meynet$^1$, André Maeder$^1$**

1 - Geneva Observatory, Geneva University

Whenever stars are rotating very fast ($\Omega/\Omega_{crit} > 0.7$, with $\Omega_{crit}$ the Keplerian angular velocity of the star accounting for its deformation) radiative stellar winds are enhanced in polar regions. This theoretical prediction is now confirmed by interferometric observations of fast rotating stars.

Polar winds remove less angular momentum than spherical winds and thus allow the star to keep more angular momentum. We quantitatively assess the importance of this effect.

First we use a semi-analytical approach to estimate the variation of the angular momentum loss when the rotation parameter increases. Then we compute complete 9 $M_\odot$ stellar models at very high angular velocities (starting on the ZAMS with $\Omega/\Omega_{crit} = 0.8$ and reaching the critical velocity during the Main Sequence) with and without radiative wind anisotropies.

When wind anisotropies are accounted for, the angular momentum loss rate is reduced by less than 4% for $\Omega/\Omega_{crit} < 0.9$ with respect to the case of spherical winds. The reduction amounts to at most 30% when the star is rotating near the critical velocity. These values result from two counteracting effects: on the one hand polar winds reduce the loss of angular momentum, on the other hand, surface deformations imply that the mass which is lost at high co-latitude is lost at a larger distance from the rotational axis and thus removes more angular momentum. Conclusions. In contrast with previous studies, which neglected surface deformations, we show that the radiative wind anisotropies have a relatively modest effect on the evolution of the angular momentum content of fast rotating stars.

**Reference:** A&A (accepted for publication)
Status: Manuscript has been accepted

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# XMM-Newton Observations Reveal Very High X-ray Luminosity from the Carbon-rich Wolf-Rayet Star WR 48a

**Svetozar A. Zhekov (1), Marc Gagne (2), Stephen L. Skinner (3)**

(1) - JILA, University of Colorado at Boulder, USA; (2) - Department of Geology and Astronomy, West Chester University, USA; (3) - CASA, University of Colorado at Boulder, USA

We present XMM-Newton observations of the dusty Wolf-Rayet star WR 48a. This is the first detection of this object in X-rays. The XMM-Newton EPIC spectra are heavily absorbed and the presence of numerous strong emission lines indicates a thermal origin of the WR 48a X-ray emission, with dominant temperature components at $kT_{cool}$ approx. 1 keV and $kT_{hot}$ approx. 3~keV, the hotter component dominating the observed flux. No significant X-ray variability was detected on time scales < 1 day. Although the distance to WR 48a is uncertain, if it is physically associated with the open clusters Danks 1 and 2 at d ~ 4 kpc, then the resultant X-ray luminosity $L_X \sim 10^{35}$ ergs/s makes it the most X-ray luminous Wolf-Rayet star in the Galaxy detected so far, after the black-hole candidate Cyg X-3. We assume the following scenarios as the most likely explanation for the X-ray properties of WR 48a: (1)

colliding stellar winds in a wide WR+O binary system, or in a hierarchical triple system with non-degenerate stellar components; (2) accretion shocks from the WR 48a wind onto a close companion (possibly a neutron star). More specific information about WR48a and its wind properties will be needed to distinguish between the above possibilities.

**Reference:** The Astrophysical Journal Letters
Status: Manuscript has been accepted

**Weblink:** http://xxx.lanl.gov/abs/1012.2211

**Comments:**

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## The kinematic characteristics of magnetic O-type stars

**S. Hubrig$^1$, N.V. Kharchenko$^{1,2}$, M. Sch"oller$^3$**

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Although magnetic fields have been discovered in ten massive O-type stars during the last years, the origin of their magnetic fields remains unknown.
Among the magnetic O-type stars, two stars, HD,36879 and HD,57682, were identified as candidate runaway stars in the past,
and $theta^1$,Ori,C was reported to move rapidly away from its host cluster.
We search for an explanation for the occurrence of magnetic fields in O-type stars by examining the assumption
of their runaway status.
We use the currently best available astrometric, spectroscopic, and photometric data to calculate
the kinematical status of seven magnetic O-type stars with previously unknown space velocities.
The results of the calculations of space velocities suggest that five out of the seven magnetic O-type stars can be considered as candidate runaway stars. Only two stars, HD,155806 and
HD,164794, with the lowest space velocities, are likely members of Sco,OB4 and NGC,6530, respectively. However, the non-thermal radio emitter HD,164794 is a binary system with colliding winds, for which
the detected magnetic field has probably a different origin in comparison to other magnetic O-type stars.

**Reference:** AN, in print
Status: Manuscript has been accepted

**Weblink:** http://arxiv.org/abs/1011.2429

**Comments:**

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# First magnetic field models for recently discovered magnetic $beta$,Cephei and slowly pulsating B stars

**S. Hubrig$^1$, I. Ilyin$^1$, M. Sch"oller$^2, M. Briquet$^3, T. Morel$^4, P. De Cat$^5$**

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In spite of recent detections of magnetic fields in a number of $beta$,Cephei and slowly pulsating B (SPB) stars, their impact on stellar rotation, pulsations, and element diffusion is not sufficiently studied yet.
The reason for this is the lack of knowledge of rotation periods, the magnetic field strength distribution and temporal variability, and the field geometry.
New longitudinal field measurements of four $beta$,Cephei and candidate $beta$,Cephei stars, and two SPB stars were acquired with FORS,2 at the VLT.
These measurements allowed us to carry out a search for rotation periods and to constrain the magnetic field geometry for four stars in our sample.

**Reference:** ApJ 726, L5
Status: Manuscript has been accepted

**Weblink:**

**Comments:**

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# Suzaku Observations of the Prototype Wind-Blown Bubble NGC 6888

**Svetozar A. Zhekov (1) and Sangwook Park (2)**

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We present an analysis of the Suzaku observations of the prototype wind-blown bubble NGC 6888 which is based both on use of standard spectral models and on a direct comparison of theoretical models with observations. The X-ray spectra of NGC 6888 are soft and most of the X-rays are in the (0.3 - 1.5 keV) energy range. But, hard X-rays (1.5 - 4.0 keV) are also detected (~10% of the observed flux). The corresponding spectral fits require a relatively cool plasma with kT < 0.5 keV but much hotter plasma with temperature kT > 2.0 keV is needed to match the observed hard X-ray emission. We find no appreciable temperature variations within the hot bubble in NGC 6888. The derived abundances (N, O, Ne) are consistent with those of the optical nebula. This indicates a common origin of the X-ray emitting gas and the outer cold shell: most of the X-ray plasma (having non-uniform spatial distribution: clumps) has flown into the hot bubble from the optical nebula. If the electron thermal conduction is efficient, this can naturally explain the relatively low plasma temperature of most of the X-ray emitting plasma. Alternatively, the hot bubble in NGC 6888 will be adiabatic and the cold clumps are heated up to X-ray temperatures likely by energy exchange between the heavy particles (hot ions diffusing into the cold clumps).

**Reference:** The Astrophysical Journal
Status: Manuscript has been accepted

**Weblink:** http://arxiv.org/abs/1012.3917

**Comments:**

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## The Quintuplet cluster II. Analysis of the WN stars

**A. Liermann[1,2], W.-R. Hamann[1], L.M. Oskinova[1], H. Todt[1], and K. Butler[3]**

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2 - now MPIfR Bonn, 53121 Bonn, Germany;

3 - Universit"ats-Sternwarte M"unchen, 81679 M"unchen, Germany

Based on $K$-band integral-field spectroscopy, we analyze four Wolf-Rayet stars of the nitrogen sequence (WN) found in the inner part of the Quintuplet cluster. All WN stars (WR102d, WR102i, WR102hb, and WR102ea) are of spectral subtype WN9h. One further star, LHO110, is included in the analysis which has been classified as Of/WN? previously but turns out to be most likely a WN9h star as well.
The Potsdam Wolf-Rayet (PoWR) models for expanding atmospheres are used to derive the fundamental stellar and wind parameters.

The stars turn out to be very luminous, $\log{(L/L_\odot)} > 6.0$, with relatively low stellar temperatures, $T_* \approx$ 25--35,kK. Their stellar winds contain a significant fraction of hydrogen, up to $X_\mathrm{H} \sim 0.45$ (by mass). We discuss the position of the Galactic center WN stars in the Hertzsprung-Russell diagram and find that they form a distinct group. In this respect, the Quintuplet WN stars are similar to late-type WN stars found in the Arches cluster and elsewhere in the Galaxy.

Comparison with stellar evolutionary models reveals that the Quintuplet WN stars should have been initially more massive than 60,$M_\odot$. They are about 2.1 to 3.6,Million years old, and might still be central hydrogen burning objects. The analysis of the spectral energy distributions of the program stars results in a mean extinction of $A_K = 3.1 \pm 0.5$,mag ($A_V = 27 \pm 4$,mag) towards the Quintuplet cluster.

**Reference:** published in Astronomy & Astrophysics 2010, Vol. 524, A82
Status: Other

**Weblink:**

**Comments:** DOI: 10.1051/0004-6361/200912612

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# Abstracts of 6 conference proceedings

## The interactions of winds from massive young stellar objects

**E. R. Parkin (1,2), J. M. Pittard (2), M. G. Hoare (2), N. J. Wright (3), J. J. Drake (3)**

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(3) Harvard-Smithsonian Center for Astrophysics, USA

The supersonic stellar and disk winds possessed by massive young stellar objects will produce shocks when they collide against the interior of a pre-existing bipolar cavity (resulting from an earlier phase of jet activity). The shock heated gas emits thermal X-rays which may be observable by spaceborne observatories such as the Chandra X-ray Observatory. Hydrodynamical models are used to explore the wind-cavity interaction. Radiative transfer calculations are performed on the simulation output to produce synthetic X-ray observations, allowing constraints to be placed on model parameters through comparisons with observations. The model reveals an intricate interplay between the inflowing and outflowing material and is successful in reproducing the observed X-ray count rates from massive young stellar objects.

**Reference:** To appear in the proceedings for "The multi-wavelength view of hot, massive stars"; 39th Liege Int. Astroph. Coll., 12-16 July 2010
Status: Conference proceedings

**Weblink:** http://arxiv.org/abs/1011.0465

**Comments:** 5 pages, 2 figures

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## The Galactic O-Star Spectroscopic Survey (GOSSS)

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IAA-CSIC, STSCI, ULS, LCO, IALP-CONICET

We present a massive spectroscopic survey of Galactic O stars, GOSSS, based on new, high signal-to-noise ratio, R ~ 2500 blue-violet digital observations from both hemispheres. The sample size and selection criteria; the relationship between GOSSS, the Galactic O-Star Catalog (GOSC), and three sister surveys (OWN, IACOB, and Lucky Imaging); the current status; and our plans for the future are discussed. We also show some of our first results, which include the new Ofc category, two new

examples of Of?p stars, a new atlas for O stars, and the introduction of the O9.7 type for luminosity classes III to V. Finally, our scientific objectives are discussed.

**Reference:** To appear in Highlights of Spanish Astrophysics VI, proceedings of the IX scientific meeting of the Spanish Astronomical Society
Status: Conference proceedings

**Weblink:** http://arxiv.org/abs/1010.5680

**Comments:**

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# Signatures of binary evolutionary processes in massive stars

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Before binary components interact, they evolve as single stars do. We therefore first critically discuss massive single star processes which affect their evolution, stellar wind mass loss and rotation in particular. Next we consider binary processes and focus on the effect of rotation on binary evolution and on the mass transfer during Roche lobe overflow. The third part highlights the importance of close pairs on the comprehension of the evolution of stellar populations in starburst regions.

**Reference:** Review to be published in 'The Multi-wavelength view of hot, massive stars', 39th Liege Int. Astroph. Coll., 12-16 July, 2010
Status: Conference proceedings

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# The most luminous stars in the Galaxy and the Magellanic Clouds

**Wolf-Rainer Hamann, Andreas Barniske, Adriane Liermann, Lidia M. Oskinova, Diana Pasemann, Ute Ruehling**

University Potsdam

Some of the Wolf-Rayet stars are found to have very high bolometric luminosities (more than 1000000 solar). We employ the Potsdam Wolf-Rayet (PoWR) model atmospheres for their spectral analysis, which yields the bolometric corrections. Distance and interstellar reddening also enter the luminosity estimates. Among the Galactic stars, there is a group of very luminous WNL stars (i.e. WR stars of late subtype from nitrogen sequence with hydrogen being depleted in their atmospheres, but not absent). Their distances are often the major source of uncertainty. From K-band spectroscopy we found a very luminous

star ($log L/L_odot = 6.5$) in the Galactic center region, which we termed the Peony Star because of the form of its surrounding dusty nebula. A similar group of very luminous WNL stars is found in the Large Magellanic Cloud (LMC). In the Small Magellanic Cloud (SMC) the majority of WR stars resides in binary systems. The single WNL stars in the SMC are not very luminous. We conclude that a significant number of very luminous WNL stars exist in the Galaxy and the LMC. With initial masses above 60$M_odot$, they apparently evolved directly to the WNL stage without a prior excursion to the red side of the HRD. At the low metallicity of the SMC, the binary channel may be dominant for the formation of WR stars.

**Reference:** To appear in the proceedings for "The multi-wavelength view of hot, massive stars"; 39th Liege Int. Astroph. Coll., 12-16 July 2010
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# X-rays, clumping and stellar wind structures

**Lidia Oskinova, Wolf-Rainer Hamann, Richard Ignace, Achim Feldmeier**

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X-ray emission is ubiquitous among massive stars. In the last decade, X-ray observations revolutionized our perception of stellar winds but opened a Pandora's box of urgent problems. X-rays penetrating stellar winds suffer mainly continuum absorption, which greatly simplifies the radiative transfer treatment. The small and large scale structures in stellar winds must be accounted for to understand the X-ray emission from massive stars. The analysis of X-ray spectral lines can help to infer the parameters of wind clumping, which is prerequisite for obtaining empirically correct stellar mass-loss rates. The imprint of large scale structures, such as CIRs and equatorial disks, on the X-ray emission is predicted, and new observations are testing theoretical expectations. The X-ray emission from magnetic stars proves to be more diverse than anticipated from the direct application of the magnetically-confined wind model. Many outstanding questions about X-rays from massive stars will be answered when the models and the observations advance.

**Reference:** Review to be published in 'The Multi-wavelength view of hot, massive stars', 39th Liege Int. Astroph. Coll., 12-16 July, 2010
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# The effect of 12C + 12C rate uncertainties on the weak s-process component

**Michael E. Bennett (1), Raphael Hirschi (1,2), Marco Pignatari (7,3,4), Steven Diehl (5), Chris Fryer (6), Falk Herwig (7), William Hillary (7), Aimee Hungerford (6), Debra Richman (7), Gabriel Rockefeller (6) , Frank X. Timmes (8), Michael Wiescher (3).**

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The contribution by massive stars (M > 9 solar masses

) to the weak s-process component of the solar system abundances is primarily due to the 22Ne neutron source, which is activated near the end of helium-core burning. The residual 22Ne left over from helium-core burning is then reignited during carbon burning, initiating further s-processing that modifies the isotopic distribution. This modification is sensitive to the stellar structure and the carbon burning reaction rate. Recent work on the 12C + 12C reaction suggests that resonances located within the Gamow peak may exist, causing a strong increase in the astrophysical S-factor and consequently the reaction rate. To investigate the effect of an increased rate, 25 solar mass stellar models with three different carbon burning rates, at solar metallicity, were generated using the Geneva Stellar Evolution Code (GENEC) with nucleosynthesis post-processing calculated using the NuGrid Multi-zone Post-Processing Network code (MPPNP). The strongest rate caused carbon burning to occur in a large convective core rather than a radiative one. The presence of this large convective core leads to an overlap with the subsequent convective carbon-shell, significantly altering the initial composition of the carbon-shell. In addition, an enhanced rate causes carbon-shell burning episodes to ignite earlier in the evolution of the star, igniting the 22Ne source at lower temperatures and reducing the neutron density.

**Reference:** Proceedings of Science, 11th Symposium on Nuclei in the Cosmos, NIC XI. July 19-23, 2010

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# JOBS

## Postdoctoral Research Assosciate Nuclear Astrophysics, North Carolina State Univ

**Dr. Carla Frohlich**

Department of Physics
Box 8202
North Carolina State University
Raleigh, NC 27695-8202

The Department of Physics at North Carolina State University has an opening for a postdoctoral research associate in the field of nuclear astrophysics. The candidate should have research experience in computational hydrodynamics, computational MHD, galactic chemical evolution or nucleosynthesis.

The successful candidate will be working with Dr. Carla Frohlich on topics of mutual interest in nuclear astrophysics.

Applicants must have a Ph.D. in physics, astronomy or a related field, with background in one of the following areas: astrophysics, particle physics or nuclear physics. Salary will be commensurate with qualifications and experience.

Interested candidates should apply by visiting NCSU's Jobs website and designate the position number 00101906. Applicants will be required to attach a CV, list of publications, and statement of research interests. Please have three letters of recommendation sent to:

Prof. C. Frohlich,
Department of Physics

North Carolina State University
Raleigh, NC 27695-8202.
carla_frohlich@ncsu.edu

Review of applications will begin February 1, 2011. The position remains open until an offer is accepted. Starting date could be as early as February 2011.

**Attention/Comments:**

**Weblink:** http://www.physics.ncsu.edu/links/101906.html

**Email:** carla_frohlich@ncsu.edu

**Deadline:** February 1, 2011 (position remains open until filled)

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