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ftp://ftp.sron.nl/pub/karelh/UPLOADS/WRBIB/

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Accepted Papers

WR 143: A Wolf-Rayet Binary

Watson P. Varricatt (1) and Nagarhalli M. Ashok (2)

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Near infrared spectroscopy and photometry of the Wolf-Rayet Star WR 143 (HD 195177) were obtained in the JHK photometric bands. High resolution spectra observed in the J and H bands exhibit narrow 1.083-micron He I line and the H I Pa Beta and the Brackett series lines in emission superposed on the broad emission line spectrum of the Wolf-Rayet star, giving strong indications of the presence of a companion. From the narrow emission lines observed, the companion is identified to be an early-type Be star. The photometric magnitudes exhibit variations in the JHK bands which are probably due to the variability of the companion star. The flux density distribution is too steep for a Wolf-Rayet atmosphere. This is identified to be mainly due to the increasing contribution from the early-type companion star towards shorter wavelengths.

Reference: MNRAS

Weblink: http://arxiv.org/abs/astro-ph/0510152

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O star swith weak winds: the Galactic case

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We study the stellar and wind properties of a sample of Galactic O dwarfs to track the conditions under which weak winds (i.e massloss rates lower than $\sim 10^{-8}$ $M_\odot$/yr) appear. The sample is composed of low and high luminosity dwarfs including Vz stars and stars known to display qualitatively weak winds. Atmosphere models including non-LTE treatment, spherical expansion and line blanketing are computed with the code CMFGEN (Hillier & Miller 1998). Both UV and H_α lines are used to derive wind properties while optical H and He lines give the stellar parameters. We find that the stars of our sample are usually 1 to 4 Myr old. Mass loss rates of all stars are found to be lower than expected from the hydrodynamical predictions of Vink et al. (2001). For stars with $\log \frac{L}{L_\odot} \gtrsim 5.2$, the reduction is by less than a factor 5 and is mainly due to the inclusion of clumping in the models. For stars with $\log \frac{L}{L_\odot} \lesssim 5.2$ the reduction can be as high as a factor 100. The inclusion of X-ray emission (possibly due to magnetic mechanisms) in models with low density is crucial to derive accurate mass loss rates from UV lines, while it is found to be unimportant for high density winds. The modified wind momentum - luminosity relation shows a significant change of slope around this transition luminosity. Terminal velocities of low luminosity stars are also found to be low. Both mass loss rates and terminal velocities of low L stars are consistent with a reduced line force parameter α. However, the physical reason for such a reduction is still not clear although the finding of weak winds in Galactic stars excludes the role of a reduced metallicity. There may be a link between an early evolutionary state and a weak wind, but this has to be confirmed by further studies of Vz stars.X-rays, through the change in the ionisation structure they imply, may be at the origin of a reduction of the radiative acceleration, leading to lower mass loss rates. A better understanding of the origin of X-rays is of crucial importance for the study of the physics of weak winds.

Reference: A&A accepted. astro-ph/0507278

Weblink: http://www.mpe.mpg.de/∼martins/publications.html

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Stellar evolution with rotation XIII: Predicted GRB rates at various Z

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We present the evolution of rotation in models of massive single stars covering a wide range of masses and metallicities. These models reproduce very well observations during the early stages of the evolution (in particular WR populations and ratio between type II and type Ib,c at different metallicities, see Meynet & Maeder 2005).

Our models predict the production of fast rotating black holes. Models with large initial masses or high metallicity end their life with less angular momentum in their central remnant with respect to the break-up limit for the remnant. Many WR star models satisfy the three main criteria (black hole formation, loss of hydrogen-rich envelope and enough angular momentum to form an accretion disk around the black hole) for gamma-ray bursts (GRB) production via the collapsar model

(Woosley 1993). Considering all types of WR stars as GRB progenitors, there would be too many GRBs compared to observations. If we consider only WO stars (type Ic supernovae as is the case for SN2003dh/GRB030329, see Matheson et al. 2003) as GRBs progenitors, the GRBs production rates are in much better agreement with observations. WO stars are produced only at low metallicities in the present grid of models. This prediction can be tested by future observations.

Reference: A&A; astro-ph/0507343

Weblink: http://arxiv.org/abs/astro-ph/0507343

Comments: 16 pages, 14 figures

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On the metallicity dependence of Wolf-Rayet winds

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We have performed a pilot study of mass loss predictions for late-type Wolf-Rayet (WR) stars as a function of metal abundance, over a range between $10^{-5} < (\mathrm{Z/Zsun}) < 10$. We find that the winds of nitrogen-rich Wolf-Rayet stars are dominated by iron lines, with a dependence of mass loss on Z similar to that of massive OB stars. For more evolved, carbon-rich, WR stars the wind strength is also found to be dependent on the Fe abundance, so that they depend on the chemical environment of the host galaxy, but with a mass loss metallicity dependence that is less steep than for OB stars. Our finding that WR mass loss is Z-dependent is a new one, with important consequences for black hole formation and X-ray population studies in external galaxies. A further finding of our study is that the Z dependence of C-rich WR stars becomes weaker at metallicities below $(\mathrm{Z/Zsun}) < 1/10$, and mass loss no longer declines once the metal abundance drops below $(\mathrm{Z/Zsun}) = 10^{-3}$. This is the result of an increased importance of radiative driving by intermediate mass elements, such as carbon. In combination with rapid rotation and/or proximity to the Eddington limit – likely to be relevant for massive Population III stars – this effect may indicate a role for mass loss in the appearance and evolution of these objects, as well as a potential role for stellar winds in enriching the intergalactic medium of the early Universe.

Reference: Accepted for Astronomy & Astrophysics

Weblink: http://astro.ic.ac.uk/∼jvink/Papers.html

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A rigidly rotating magnetosphere model for circumstellar emission from magnetic OB stars

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We present a semi-analytical approach for modelling circumstellar emission from rotating hot stars with a strong dipole magnetic field tilted at an arbitrary angle to the rotation axis. By assuming the

rigid-field limit in which material driven (e.g. in a wind outflow) from the star is forced to remain in strict rigid-body corotation, we are able to solve for the effective centrifugal-plus-gravitational potential along each field line, and thereby identify the location of potential minima where material is prone to accumulate. Applying basic scalings for the surface mass flux of a radiatively driven stellar wind, we calculate the circumstellar density distribution that obtains once ejected plasma settles into hydrostatic stratification along field lines. The resulting accumulation surface resembles a rigidly rotating, warped disc, tilted such that its average surface normal lies between the rotation and magnetic axes. Using a simple model of the plasma emissivity, we calculate time-resolved synthetic line spectra for the disc. Initial comparisons show an encouraging level of correspondence with the observed rotational phase variations of Balmer-line emission profiles from magnetic Bp stars such as σ Ori E.

Reference: 2005, MNRAS, 357, 251

Weblink: http://www.star.ucl.ac.uk/∼rhdt/publications/

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The rigidly rotating magnetosphere of σ Ori E

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We attempt to characterize the observed variability of the magnetic helium-strong star σ Ori E in terms of a recently developed rigidly rotating magnetosphere model. This model predicts the accumulation of circumstellar plasma in two co-rotating clouds, situated in magnetohydrostatic equilibrium at the intersection between magnetic and rotational equators. We find that the model can reproduce well the periodic modulations observed in the star's light curve, Hα emission-line profile, and longitudinal field strength, confirming that it furnishes an essentially correct, quantitative description of the star's magnetically controlled circumstellar environment.

Reference: ApJL

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Chemical composition of Galactic OB stars II. The fast rotator Z Oph

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Z Oph, HD149757, is an O9.5 Vnn star with a very high projected rotational velocity ($v \sin i \gtrsim 340$ km/s). It is also a classical runaway star due to its high proper motion. We perform a quantitative analysis of its optical spectrum in order to measure important observables of the star such as its mass, effective temperature, luminosity and He, C, N, and O abundances. Comparing these observed values to those predicted by the rotating evolutionary models of the Geneva group we find that none of the two sets of models is capable of reproducing the characteristics of the star. Nevertheless, due to its

runaway nature, the reason for this discrepancy may be that the star is not the result of the evolution of a single object, but the product of the evolution of a close binary system.

Reference: A&A 2005 (in press)

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On the evolutionary status of Be stars. I. Field Be stars near the Sun

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A sample of 97 galactic field Be stars were studied by taking into account the effects induced by the fast rotation on their fundamental parameters. All program stars were observed in the BCD spectrophotometric system in order to minimize the perturbations produced by the circumstellar environment on the spectral photospheric signatures. This is one of the first attempts at determining stellar masses and ages by simultaneously using model atmospheres and evolutionary tracks, both calculated for rotating objects. The stellar ages (τ) normalized to the respective inferred time that each rotating star can spend in the main sequence phase ($\tau_{\rm MS}$) reveal a mass-dependent trend. This trend shows that: a) there are Be stars spread over the whole interval $0 \lesssim \tau/\tau_{\rm MS} \lesssim 1$ of the main sequence evolutionary phase; b) the distribution of points in the $(\tau/\tau_{\rm MS}, M/M_\odot)$ diagram indicates that in massive stars ($M \gtrsim 12M_\odot$) the Be phenomenon is present at smaller $\tau/\tau_{\rm MS}$ age ratios than for less massive stars ($M \lesssim 12M_\odot$). This distribution can be due to: *i*) higher mass-loss rates in massive objets, which can act to reduce the surface fast rotation; *ii*) circulation time scales to transport angular momentum from the core to the surface, which are longer the lower the stellar mass.

Reference: Astronomy and Astrophysics

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The [O III] Veil: Astropause of Eta Carinae's Wind?

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We present narrowband images of eta Carinae in the light of [O III] 5007 obtained with HST/WFPC2, as well as a ground-based image in the same emission line with a larger field of view. These images show a thin veil of [O III] emission around eta Car and its ejecta, confirming the existence of an oxygen-bearing "cocoon" inferred from spectra. This [O III] veil may be the remnant of the pre-outburst wind of eta Car, and its outer edge probably marks the interface where eta Car's ejecta meet the stellar wind of the nearby O4 V((f)) star HD303308 or other ambient material – i.e., it marks the "astropause" in eta Car's wind. This veil is part of a more extensive [O III] shell that appears to be shaped and ionized by HD303308. A pair of HST images with a 10 yr baseline shows no proper motion, limiting the expansion speed away from eta Car to 12pm13 km/s, or an expansion age of a few times 10^4 yr. Thus, this is probably the decelerated pre-outburst LBV wind of eta Car.

The [O II

Reference: AJ OCtober 2005

Weblink: http://xxx.lanl.gov/abs/astro-ph/0507187

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Spectral analysis of early-type stars using a genetic algorithm based fitting method

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We present the first automated fitting method for the quantitative spectroscopy of O- and early B-type stars with stellar winds. The method combines the non-LTE stellar atmosphere code FASTWIND from Puls et al. (2005) with the genetic algorithm based optimizing routine PIKAIA from Charbonneau (1995), allowing for a homogeneous analysis of upcoming large samples of early-type stars (e.g. Evans et al. 2005). In this first implementation we use continuum normalized optical hydrogen and helium lines to determine photospheric and wind parameters. We have assigned weights to these lines accounting for line blends with species not taken into account, lacking physics, and/or possible or potential problems in the model atmosphere code. We find the method to be robust, fast, and accurate. Using our method we analysed seven O-type stars in the young cluster Cyg OB2 and five other Galactic stars with high rotational velocities and/or low mass loss rates (including 10 Lac, ζ Oph, and τ Sco) that have been studied in detail with a previous version of FASTWIND. The fits are found to have a quality that is comparable or even better than produced by the classical "by eye" method. We define errorbars on the model parameters based on the maximum variations of these parameters in the models that cluster around the global optimum. Using this concept, for the investigated dataset we are able to recover mass-loss rates down to $\sim 6 \times 10^{-8}$ $M_{\odot}\mathrm{yr}^{-1}$ to within an error of a factor of two, ignoring possible systematic errors due to uncertainties in the continuum normalization. Comparison of our derived spectroscopic masses with those derived from stellar evolutionary models are in very good agreement, i.e. based on the limited sample that we have studied we do not find indications for a mass discrepancy. For three stars we find significantly higher surface gravities than previously reported. We identify this to be due to differences in the weighting of Balmer line wings between our automated method and "by eye" fitting and/or an improved multidimensional optimization of the parameters. The empirical modified wind momentum relation constructed on the basis of the stars analysed here agrees to within the error bars with the theoretical relation predicted by Vink et al. (2000), including those cases for which the winds are weak (i.e. less than a few times 10^{-7} $M_{\odot}\mathrm{yr}^{-1}$).

Reference: A&A in press

Weblink: http://xxx.lanl.gov/abs/astro-ph/0506751

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A Medium Resolution Near-Infrared Spectral Atlas of O and Early B Stars

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We present intermediate resolution (R $\sim$ 8,000 - 12,000) high signal-to-noise H- and K-band spectroscopy of a sample of 37 optically visible stars, ranging in spectral type from O3 to B3 and representing most luminosity classes. Spectra of this quality can be used to constrain the temperature, luminosity and general wind properties of OB stars, when used in conjunction with sophisticated atmospheric model codes. Most important is the need for moderately high resolutions (R $>$ 5000) and very high signal-to-noise (S/N $>$ 150) spectra for a meaningful profile analysis. When using near-infrared spectra for a classification system, moderately high signal-to-noise (S/N $\sim$ 100) is still required, though the resolution can be relaxed to just a thousand or two. In the appendix we provide a set of very high quality near-infrared spectra of Brackett lines in six early-A dwarfs. These can be used to aid in the modeling and removal of such lines when early-A dwarfs are used for telluric spectroscopic standards.

Reference: To appear in ApJ Supp, November 2005

Weblink: http://arxiv.org/abs/astro-ph/0506705

Comments: All spectra are available by contacting M.M. Hanson

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Multiwavelength studies of WR 21a and its surroundings

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We present results of high-resolution radio continuum observations towards the binary star WR 21a (Wack 2134) obtained with the Australia Telescope Compact Array (ATCA) at 4.8 and 8.64 GHz. We detected the system at 4.8 GHz (6 cm) with a flux density of 0.25+-0.06 mJy and set an upper limit of 0.3 mJy at 8.64 GHz (3 cm). The derived spectral index of alpha $<$ 0.3 ($S_\nu = k\ .\ \nu^\alpha$) suggests the presence of non-thermal emission, probably originating in a colliding-wind region. A second, unrelated radio source was detected $\sim$10" north of WR 21a at (RA, Dec)(J2000)=(10h 25m 56.49s, –57deg 48' 34.4"), with flux densities of 0.36 and 0.55 mJy at 4.8 and 8.64 GHz, respectively, resulting in alpha = 0.72. HI observations in the area are dominated by absorption against the prominent H II region RCW 49. Analysis of a complete set of archived X-ray observations of WR 21a confirms its strong variability but throws into doubt previous suggestions by Reig (1999) of a period of years for the system. Finally, we comment on the association with the nearby EGRET source 3EG J1027-5817.

Reference: A&A, in press

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Dust-enshrouded giants in clusters in the Magellanic Clouds

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We present the results of an investigation of post-Main Sequence mass loss from stars in clusters in the Magellanic Clouds, based around an imaging survey in the L'-band (3.8 micron) performed with the VLT at ESO. The data are complemented with JHKs (ESO and 2MASS) and mid-IR photometry (TIMMI2 at ESO, ISOCAM on-board ISO, and data from IRAS and MSX). The goal is to determine the influence of initial metallicity and initial mass on the mass loss and evolution during the latest stages of stellar evolution. Dust-enshrouded giants are identified by their reddened near-IR colours and thermal-IR dust excess emission. Most of these objects are Asymptotic Giant Branch (AGB) carbon stars in intermediate-age clusters, with progenitor masses between 1.3 and about 5 Msun. Red supergiants with circumstellar dust envelopes are found in young clusters, and have progenitor masses between 13 and 20 Msun. Post-AGB objects (e.g., Planetary Nebulae) and massive stars with detached envelopes and/or hot central stars are found in several clusters. We model the spectral energy distributions of the cluster IR objects, in order to estimate their bolometric luminosities and mass-loss rates. The IR objects are the most luminous cluster objects, and have luminosities as expected for their initial mass and metallicity. They experience mass-loss rates in the range from a few 1e-6 up to 1e-4 Msun/yr (or more), with most of the spread being due to evolutionary effects and only a weak dependence on progenitor mass and/or initial metallicity. About half of the mass lost by 1.3–3 Msun stars is shed during the superwind phase, which lasts of order 1e5 yr. Objects with detached shells are found to have experienced the highest mass-loss rates, and are therefore interpreted as post-superwind objects. We also propose a simple method to measure the cluster mass from L'-band images.

Reference: Astronomy and Astrophysics

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A Statistical Study of Threshold Rotation Rates for the Formation of Disks around Be Stars

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This paper presents a detailed statistical determination of the equatorial rotation rates of classical Be stars. The rapid rotation of Be stars is likely to be linked to the ejection of gas that forms dense circumstellar disks. The physical origins of these disks are not understood, though it is generally believed that the ability to spin up matter into a Keplerian disk depends on how close the stellar rotation speed is to the critical speed at which the centrifugal force cancels gravity. There has been recent disagreement between the traditional idea that Be stars rotate between 50 and 80 percent of their critical speeds and new ideas (inspired by the tendency for gravity darkening to mask rapid rotation at the equator) that their rotation may be very nearly critical. This paper utilizes Monte Carlo forward modeling to simulate distributions of the projected rotation speed (v sin i), taking into account gravity darkening, limb darkening, and observational uncertainties. A chi-squared minimization procedure was

used to find the distribution parameters that best reproduce observed v sin i distributions from R. Yudin's database. Early-type (O7e-B2e) Be stars were found to exhibit a roughly uniform spread of intrinsic rotation speed that extends from 40 to 60 percent up to 100 percent of critical. Late-type (B3e-A0e) Be stars exhibit progressively narrower ranges of rotation speed as the effective temperature decreases; the lower limit rises to reach critical rotation for the coolest Be stars. The derived lower limits on equatorial rotation speed represent conservative threshold rotation rates for the onset of the Be phenomenon. The significantly subcritical speeds found for early-type Be stars represent strong constraints on physical models of angular momentum deposition in Be star disks.

Reference: ApJ, in press (November 20, 2005), astro-ph/0507718

Weblink: http://arXiv.org/abs/astro-ph/0507718

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A photometric study of 11 massive stars in the Magellanic Clouds

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We present and discuss $VBLUW$ photometry of eleven massive stars in the Magellanic Clouds: the SMC stars AzV 121, AzV 136 = HD 5277 = R 10, AzV 197, AzV 310 = R 26 and AzV 369, and the LMC stars GV 80 = HD 32034 = R 62, GV 91 = HDE 268 819, GV 346 = HDE 269 661 = R 111, GV 352 = HDE 269 697, GV 423 = HDE 269 953 = R 150 and GV 460 = HDE 270 111. Only one G0 Ia SMC supergiant is found to be variable, whereas all members of the LMC sample show definite variability. We find that roughly above M/$M_{\odot}$= 25, supergiants become photometrically unstable. The reddening-independent metal-index $[B-L]$ is used to investigate the metallicity of late-type supergiants in both galaxies relative to similar supergiants in the solar neighbourhood.

Reference: Astronomische Nachrichten (AN), in press

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Stellar Winds and Embedded Star Formation in the Galactic Center Quintuplet and Arches Clusters: Multifrequency Radio Observations

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A multi-frequency, multi-configuration study has been made of the compact radio sources in the Galactic Center Quintuplet and Arches stellar clusters using the Very Large Array. Ten radio sources have been detected in the Quintuplet cluster. The majority of these radio sources have rising spectral indices and are positionally coincident with young massive stars that are known to have powerful stellar winds. We conclude that the three most compact of these sources are produced by stellar

wind emission; thus, mass-loss rates can be derived and have an average value of $3{\times}10^{-5}$ $M_\odot$ yr^{-1}. The remainder of the sources are likely to be a combination of stellar wind emission and free-free emission from surrounding ionized gas. In three cases, the radio sources have no stellar counterpart and the radio emission is thought to arise from compact or ultra-compact HII regions. If so, these sources would be the first detections of embedded massive stars to be discovered in the Galactic center clusters. The radio nebula associated with the Pistol star resembles the nebula surrounding the LBV star η Carina and may be related to the stellar wind of the Pistol star. Ten compact radio sources are detected in the Arches cluster and are interpreted to be stellar wind sources, consistent with previous findings. Several of the sources show moderate variability (10-30%) in their flux density, possibly related to a nonthermal component in the wind emission. A number of radio sources in both clusters have X-ray counterparts, which have been interpreted to be the shocked, colliding winds of massive binary systems.

Reference: In press, Astronomical Journal, November 2005

Weblink: http://xxx.lanl.gov/abs/astro-ph/0508178

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The Reddenings of Red Supergiants: When Smoke Gets In Your Eyes

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Deriving the physical properties of red supergiants (RSGs) depends upon accurate corrections for reddening by dust. We use our recent modeling of the optical spectra of RSGs to address this topic. First, we find that previous broad-band studies have underestimated the correction for extinction in the visible, and hence the luminosities (if derived from V); the shift in the effective wavelengths of the standar B and V bandpasses necessitates using an *effective* value of the ratio $R'_V = 4.2$ to correct broad-band photometry of RSGs if $R_V = 3.1$ for early-type stars viewed through the same dust, where we have assumed the standard reddening law of Cardelli, Clayton, & Mathis (1989). Use of the Fitzpatrick (1999) reddening law would lead to $R'_V = 3.8$, as well as slightly lower values of extinction derived from spectrophotometry, but results in slightly poorer fits. Second, we find that a significant fraction of RSGs in Galactic OB associations and clusters show up to several magnitudes of excess visual extinction compared to OB stars in the same regions; we argue that this is likely due to circumstellar dust around the RSGs. We also show that the RSG dust production rate (as indicated by the 12-μm excess) is well-correlated with bolometric luminosity, contrary to what has been found by earlier studies. The stars with the highest amount of extra visual extinction also show significant near-UV (NUV) excesses compared to the stellar models reddened by the standard reddening law. This NUV excess is likely due to scattering of the star's light by the dust and/or a larger average grain size than that typical of grains found in the diffuse interstellar medium. Similar excesses have been attributed to circumstellar dust around R Coronae Borealis stars. Finally, we estimate that the RSGs contribute dust grains at the rate of $3 \times 10^{-8} M_\odot$ yr^{-1} kpc^{-2} in the solar neighborhood, comparable to what we estimate for late-type WCs, $1 \times 10^{-7} M_\odot$ yr^{-1} kpc^{-2}. In the solar neighborhood this represents only a few percent of the dust production (which is dominated by low-mass AGBs), but we note that in low-metallicity starbursts, dust production by RSGs would likely dominate over other sources.

Reference: ApJ 634, in press (Dec 1, 2005)

Weblink: http://www.lowell.edu/users/massey/smokefinal.pdf

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Meridional Circulation in Young Massive Stars with Shellular Rotation.

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We study the rotation of a chemically homogeneous star with a mass of 16 M$-\odot$, assuming that the angular-momentum distribution in its radiative envelope is determined by hydrodynamical processes - flows and turbulent diffusion. Meridional circulation and horizontal shear turbulence are the main hydrodynamical processes forming the radial distribution of the angular momentum in young massive stars in the absence of magnetic fields. The rotation of such stars is close to steady-state. The angular velocity of rotation of the convective core can be $\sim$5-20% higher than the surface value. Under these conditions, the characteristic time for the radial transport of angular momentum by meridional flows and shear turbulence is comparable to the nuclear time scale.

Reference: Astronomy Reports, No.8 (in press)

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Insights into the Carbon chemistry of Mon R2

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Aiming to learn about the chemistry of the dense PDR around the ultracompact (UC) HII region in Mon R2, we have observed a series of mm-wavelength transitions of C_3H_2 and C_2H. In addition, we have traced the distribution of other molecules, such as $H^{13}CO^+$, SiO, HCO, and HC_3N. These data, together with the reactive ions recently detected, have been considered to determine the physical conditions and to model the PDR chemistry. We then identified two kind of molecules. The first group, formed by the reactive ions (CO^+, HOC^+) and small hydrocarbons (C_2H, C_3H_2), traces the surface layers of the PDR and is presumably exposed to a high UV field (hence we called it as "*high UV*", or HUV). HUV species is expected to dominate for visual absorptions $2 < A_V < 5$ mag. A second group (less exposed to the UV field, and hence called "*low UV*", or LUV) includes HCO and SiO, and is mainly present at the edges of the PDR ($A_V > 5$ mag). While the abundances of the HUV molecules can be explained by gas phase models, this is not the case for the studied LUV ones. Although some efficient gas-phase reactions might be lacking, grain chemistry sounds like a probable mechanism able to explain the observed enhancement of HCO and SiO. Within this scenario, the interaction of UV photons with grains produces an important effect on the molecular gas chemistry and constitutes the first evidence of an ionization front created by the UC HII region carving its host molecular cloud. The physical conditions and kinematics of the gas layer which surrounds the UC HII region were derived from the HUV molecules. Molecular hydrogen densities $> 4\,10^6$ cm^{-3} are required to reproduce the observations. Such high densities suggest that the HII region could be pressure-confined by the surrounding high density molecular gas.

Reference: Astrophysical Journal, in press

Weblink: astro-ph/0508311

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Observations and Modeling of the 2-25 microns Emission from High Mass Protostellar Object Candidates

James M. De Buizer, Mayra Osorio, Nuria Calvet

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This is a report on detailed modeling of young high-mass protostellar candidates during their most embedded and obscured phases. We performed narrowband mid-infrared imaging of three candidate high-mass protostellar objects in G11.94-0.62, G29.96-0.02, and G45.07+0.13 at Gemini Observatory using the Thermal-Region Camera and Spectrograph (T-ReCS). The sources were imaged through up to 11 narrowband filters, sampling their SEDs over the entire 2–25 micron infrared range. For the first time, we have fitted the observed SEDs of massive protostars with models that take into account departures from spherical symmetry in the infalling envelopes. In this way, we have been able to back out of the models detailed physical parameters for these earliest stages of massive stellar life. Our detailed modeling suggests that massive star formation can proceed in a way very similar to the formation of low-mass stars

Reference: astro-ph/0508376 and Astrophysical Journal 635, p. 452

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Bright OB stars in the Galaxy. II. Wind variability in O supergiants as traced by H-alpha

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(3) INAF - Osservatorio Astrofisico di Catania, Italy

We investigate the line-profile variability (lpv) of H-alpha for a large sample of O-type supergiants (15 objects between O4 and O9.7), in an objective, statistically rigorous manner. We employed the Temporal Variance Spectrum (TVS) analysis, developed for the case of photospheric absorption lines and modified by us to take into account the effects of wind emission. By means of a comparative analysis we place constraints on the properties of this variability - quantified in terms of a mean and a newly defined fractional amplitude of deviations - as a function of stellar and wind parameters. The results of our analysis show that all the stars in the sample show evidence of significant lpv in H-alpha, mostly dominated by processes in the wind. The variations occur between zero and 0.3 v-inf (i.e., below ∼1.5 R-star), in good agreement with results from similar studies.

A comparison between the observations and corresponding line-profile simulations indicates that for stars with intermediate wind densities the properties of the H-alpha variability can be explained by simple models consisting of coherent or broken shells blobs uniformly distributed over the wind

volume, with an intrinsic scatter in the maximum density contrast of about a factor of two. For stars at lower and higher wind densities, on the other hand, we found certain inconsistencies between the observations and our predictions, most importantly concerning the mean amplitude and the symmetry properties of the TVS. This disagreement might be explained by the presence of coherent large-scale structures, partly confined in a volume close to the star.

Interpreted in terms of a variable mass-loss rate, the observed variations of H-alpha indicate changes of +/-4% with respect to the mean value of $\dot{M}$for stars with stronger winds and of +/- 16% for stars with weaker winds. The effect of these variations on the corresponding wind momenta is rather insignificant (less than 0.16 dex), increasing only the local scatter without affecting the Wind Momentum Luminosity Relationship.

Reference: A&A 440 (in press)

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An Ultraviolet to Mid-Infrared Study of the Physical and Wind Properties of HD 164270 (WC9) and Comparison to BD+30 3639 ([WC9])

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1: Sheffield; 2: Caltech, 3: Steward Obs

We present new Spitzer IRS observations of HD164270 (WC9, WR103). A quantitative analysis of the UV, optical, near- and mid-IR spectrum of HD164270 is presented, allowing for line blanketing and wind clumping, revealing T* $\sim$ 48kK, log L/$L_{\odot}\sim$ 4.9, dM/dt $\sim$ 1e-5 $M_{\odot}$/yr for a volume filling factor of f $\tilde{0}$.1. Our models predict that He is partially recombined in the outer stellar wind, such that recent radio-derived mass-loss rates of WC9 stars have been underestimated. We obtain C/He $\sim$ 0.2 and O/He $\sim$ 0.01 by number from optical diagnostics. Mid-IR fine structure lines of [NeII] 12.8 and [SIII] 18.7micron are observed, with [NeIII] and [SIV] absent. From these we obtain Ne/He $\sim$ Ne^{+}/He = 2.2e-3 by number, 7 times higher than the Solar value (as recently derived by Asplund et al.), and S/He $\sim$ S^{2}+/He = 5.1e-5 by number. From a comparison with similar results for other WC subtypes we conclude that WC9 stars are as chemically advanced as earlier subtypes.

We consider why late WC stars are exclusively observed in high metallicity environments. In addition, we compare the UV/optical/mid-IR spectroscopic morphology of HD164270 with the Planetary Nebula central star BD+30 3639 ([WC9]). Their UV and optical signatures are remarkably similar, such that our quantitative comparisons confirm similarities in stellar temperature, wind densities and chemistry first proposed by Smith & Aller, in spite of completely different evolutionary histories, with HD164270 presently a factor of ten more massive than BD+30 3639. At mid-IR wavelengths, the dust from the dense young, nebula of BD+30 3639 completely dominates its appearance, in contrast with HD164270.

Reference: Accepted for ApJ

Weblink: http://arxiv.org/abs/astro-ph/0509343

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Physical Parameters and Wind Properties of Galactic Early B Supergiants

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We present optical studies of the physical and wind properties, plus CNO chemical abundances, of 25 O9.5-B3 Galactic supergiants. We employ non-LTE, line blanketed, extended model atmospheres, which provide a modest downward revision in the effective temperature scale of early B supergiants of up to 1-2kK relative to previous non-blanketed results. The so-called 'bistability jump' at B1 (Teff $\sim$ 21kK) from Lamers et al. is rather a more gradual trend (with large scatter) from $v_\infty/v_{\rm esc}\sim$ 3.4 for B0–0.5 supergiants above 24kK to $v_\infty/v_{\rm esc}\sim$ 2.5 for B0.7-1 supergiants with 20kK $<$ Teff $<$ 24kK, and $v_\infty/v_{\rm esc}\sim$ 1.9 for B1.5-3 supergiants below 20kK. This, in part, explains the break in observed UV spectral characteristics between B0.5 and B0.7 subtypes as discussed by Walborn et al. We compare derived (homogeneous) wind densities with recent results for Magellanic Cloud B supergiants and generally confirm theoretical expectations for stronger winds amongst Galactic supergiants.

However, winds are substantially weaker than predictions from current radiatively driven wind theory, especially at mid-B subtypes, a problem which is exacerbated if winds are already clumped in the H-alpha line forming region. In general, CNO elemental abundances reveal strongly processed material at the surface of Galactic B supergiants, with mean N/C and N/O abundances 10 and 5 times higher than the Solar value, respectively, with HD 2905 (BC0.7 Ia) indicating the lowest degree of processing in our sample, and HD 152236 (B1.5 Ia+) the highest.

Reference: 18 pages, 9 figures, accepted for A&A

Weblink: http://arxiv.org/abs/astro-ph/0509436

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The winds of hot massive first stars

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Astronomical Institute, Ondrejov, Czech Republic

We study dynamical aspects of circumstellar environment around massive zero-metallicity first stars. For this purpose we apply our NLTE wind models. We show that the hydrogen-helium stellar wind from stationary massive first generation (Population III) stars (driven either by the line (bound-bound) or continuum (bound-free and free-free) transitions) is unlikely. The possibility of expulsion of chemically homogeneous wind and the role of minor isotopes are also discussed. Finally, we estimate the importance of hydrogen and helium lines for shutting off the initial accretion onto first stars and its influence on initial mass function of first stars.

Reference: Accepted for publication in Astronomy & Astrophysics

Weblink: http://xxx.lanl.gov/abs/astro-ph/0509171

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Non-LTE modelling of the HeI 10830A line in early-type main sequence stars

N. Przybilla

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The near-IR HeI 10830A transition is a highly sensitive diagnostic for non-LTE effects in the helium atom. So far, non-LTE line-formation computations have failed to quantitatively reproduce observations of this line in the entire range of early-A to late-O main sequence stars. It is shown that the non-LTE modelling was insufficient, for the most part either because of inaccurate photoionization cross-sections for the 2s 3S state or the neglect of line blocking. New calculations based on state-of-the-art atomic data give excellent agreement with observation for the HeI 10830 A feature, while profiles of the HeI lines in the visual are retained.

Reference: A&A (in press)

Weblink: http://arxiv.org/pdf/astro-ph/0508068

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Quantitative Spectroscopy of BA-type Supergiants

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Luminous BA-type supergiants have enormous potential for modern astrophysics. They allow topics ranging from non-LTE physics and the evolution of massive stars to the chemical evolution of galaxies and cosmology to be addressed. A hybrid non-LTE technique for the quantitative spectroscopy of these stars is discussed. Thorough tests and first applications of the spectrum synthesis method are presented for the bright Galactic objects eta Leo (A0 Ib), HD111613 (A2 Iabe), HD92207 (A0 Iae) and beta Ori (B8 Iae), based on high-resolution and high-S/N Echelle spectra. Stellar parameters are derived from spectroscopic indicators, consistently from multiple non-LTE ionization equilibria and Stark-broadened hydrogen line profiles, and they are verified by spectrophotometry. The internal accuracy of the method allows the 1sigma-uncertainties to be reduced to <=1-2% in Teff and to 0.05-0.10dex in log g.

Elemental abundances are determined for over 20 chemical species, with many of the astrophysically most interesting in non-LTE (H, He, C, N, O, Mg, S, Ti, Fe). The non-LTE computations reduce random errors and remove systematic trends in the analysis. Inappropriate LTE analyses tend to systematically underestimate iron group abundances and overestimate the light and alpha-process element abundances by up to factors of two to three on the mean. This is because of the different responses of these species to radiative and collisional processes in the microscopic picture, which is explained by fundamental differences of their detailed atomic structure, and not taken into account in LTE. Contrary to common assumptions, significant non-LTE abundance corrections of ∼0.3dex can be found even for the weakest lines (Wλ <10mA). Non-LTE abundance uncertainties amount to typically 0.05-0.10dex (random) and ∼0.10dex (systematic 1sigma-errors). Near-solar abundances are derived for the heavier elements in the sample stars, and patterns indicative of mixing with nuclear-processed matter for the light elements. These imply a blue-loop scenario for eta Leo because of first dredge-up abundance ratios, while the other three objects appear to have evolved directly from the main

sequence. In the most ambitious computations several ten-thousand spectral lines are accounted for in the spectrum synthesis, permitting the accurate reproduction of the entire observed spectra from the visual to near-IR. This prerequisite for the quantitative interpretation of intermediate-resolution spectra opens up BA-type supergiants as versatile tools for extragalactic stellar astronomy beyond the Local Group. The technique presented here is also well suited to improve quantitative analyses of less extreme stars of similar spectral types.

Reference: A&A (in press)

Weblink: http://arxiv.org/pdf/astro-ph/0509669

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Quantitative H and K band spectroscopy of Galactic OB-stars at medium resolution

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In this paper we have analyzed 25 Galactic O and early B-stars by means of *H* and *K* band spectroscopy, with the primary goal to investigate to what extent a lone near-IR spectroscopy is able to recover stellar and wind parameters derived in the optical. Most of the spectra have been taken with SUBARU-IRCS, at an intermediate resolution of 12,000, and with a very high S/N, mostly on the order of 200 or better. In order to synthesize the strategic H/He lines, we have used our recent, line-blanketed version of FASTWIND (Puls et al. 2005). In total, seven lines have been investigated, where for two stars we could make additional use of the HeI2.05 singlet which has been observed with IRTF-CSHELL. Apart from Br-gamma and HeII2.18, the other lines are predominately formed in the stellar photosphere, and thus remain fairly uncontaminated from more complex physical processes, particularly clumping.

First we investigated the predicted behaviour of the strategic lines. In contradiction to what one expects from the optical in the O-star regime, almost all photospheric H/HeI/HeII *H/K* band lines *become stronger if the gravity decreases*. Concerning H and HeII, this finding is related to the behaviour of Stark broadening as a function of electron density, which in the line cores is different for members of lower (optical) and higher (IR) series. Regarding HeI, the predicted behaviour is due to some subtle NLTE effects resulting in a stronger overpopulation of the lower level when the gravity decreases.

We have compared our calculations with results from the alternative NLTE model atmosphere code CMFGEN (Hillier & Miller 1998). In most cases, we found reasonable or nearly perfect agreement. Only the HeI2.05 singlet for mid O-types suffers from some discrepancy, analogous with findings for the optical HeI singlets.

For most of our objects, we obtained good fits, except for the line cores of Br-gamma in early O-stars with significant mass-loss. Whereas the observations show Br-gamma mostly as rather symmetric emission lines, the models predict a P Cygni type profile with strong absorption. This discrepancy (which also appears in lines synthesized by CMFGEN) might be an indirect effect of clumping.

After having derived the stellar and wind parameters from the IR, we have compared them to results from previous optical analyses. Overall, the IR results coincide in most cases with the optical ones

within the typical errors usually quoted for the corresponding parameters, i.e, an uncertainty in Teff of 5%, in log g of 0.1 dex and in $\dot{M}$of 0.2 dex, with lower errors at higher wind densities. Outliers above the 1-sigma level where found in four cases with respect to log g and in two cases for $\dot{M}$.

Reference: A&A 440, 261

Weblink: http://www.usm.uni-muenchen.de/people/puls/Puls.html

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Submitted Papers

Constraints on gamma-ray burst and supernova progenitors through circumstellar absorption lines

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Long gamma-ray bursts are thought to be caused by a subset of exploding Wolf-Rayet stars. We argue that the circumstellar absorption lines in early supernova and in gamma-ray burst afterglow spectra may allow us to determine the main properties of the Wolf-Rayet star progenitors which can produce those two events. To demonstrate this, we first simulate the hydrodynamic evolution of the circumstellar medium around a 40 Msun star from the creation and evolution of a wind-blown, photo-ionized bubble around the star up to the time of the supernova explosion. Knowledge of density, temperature and radial velocity of the circumstellar matter as function of space and time allows us to compute the column density in the line of sight to the centre of the nebula, as a function of radial velocity, angle and time. While without radiative transfer modeling and without detailed knowledge of the spatial distribution of chemical elements we cannot produce spectra, our column density profiles indicate the possible number, strengths, widths and velocities of absorption line components in supernova and gamma-ray burst afterglow spectra. Our example calculation shows four distinct line features during the Wolf-Rayet stage, at about 0, 50, 150-700 and 2200 km/s, with only those of the lowest and highest velocity present at all times. The 150-700 km/s feature decays rapidly as function of time after the onset of the Wolf-Rayet stage. It consists of a variable number of components, and, especially in its evolved stage, is depending strongly on the particular line of sight. A comparison with absorption lines detected in the afterglow of GRB 021004 suggests that the high velocity absorption component in GRB 021004 may be attributed to the free streaming Wolf-Rayet wind, which is consistent with the steep density drop indicated by the afterglow light curve. The presence of the intermediate velocity components implies that the duration of the Wolf-Rayet phase of the progenitor of GRB 021004 was much smaller than the average Wolf-Rayet life time, which strongly constrains its progenitor evolution.

Reference: Astronomy & Astrophysics

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An Extreme Case of a Misaligned Highly Flattened Wind in the Wolf-Rayet Binary CX Cephei

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CX Cep (WR 151) is the WR+O binary (WN5+O5V) with the second shortest period known in our Galaxy. To examine the circumstellar matter distribution and to better constraint the orbital parameters and mass-loss rate of the WR star, we obtained broadband and multi-band (i.e. UBVRI) linear polarization observations of the system. Our analysis of the phase-locked polarimetric modulation confirms the high orbital inclination of the system (i.e. $i = 65^o$). Using the orbital solution of Lewis et al. (1993) we obtain masses of $33.9M_\odot$ and $23.9M_\odot$ for the O and WR stars respectively, which agree with their spectral types. A simple polarimetric model accounting for finite stellar size effects allowed us to derive a mass-loss rate for the WR star of $0.3 - 0.5 \times 10^{-5} M_\odot/yr$. This result was remarkably independent of the model's input parameters and favors an earlier spectral type for the WR component (i.e. WN4). Finally, using our multi-band observations, we fitted and subtracted from our data the interstellar polarization. The resulting constant intrinsic polarization of $3 - 4\%$ is misaligned in relation to the orbital plane (i.e. $\theta_{CIP} = 26^o$ vs. $\Omega = 75^o$) and is the highest intrinsic polarization ever observed for a WR star. This misalignment points towards a rotational (or magnetic) origin for the asymmetry and contradicts the most recent evolutionary models for massive stars (Meynet & Maeder 2003) which predict spherically symmetric winds during the WR phase (i.e. $CIP = 0\%$).

Reference: Astrophysical Journal

Weblink: http://arxiv.org/abs/astro-ph/0507616

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In Proceedings

X-raying the super star clusters in the Galactic center

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The Galactic center harbors some of the most massive star clusters known in the Galaxy: the Arches and the Quintuplet. Based on the Chandra observations of these clusters (PI: Wang) which recently became public, I discuss the X-ray emission from the massive stars in these clusters. Confirming the general trend for Wolf-Rayet (WR) stars being X-ray dim, none of them is detected in the Quintuplet cluster. The most massive star known in the Galaxy, the Pistol star, is also not detected, invoking questions regarding the proposed binary nature of this object. X-ray emission in the Arches cluster is dominated by three stellar point sources. All three sources as well as the cluster's diffuse radiation show strong emission at 6.4-6.7 keV, indicating the presence of fluorescenting cool material. The Arches point sources may be identified as colliding wind binaries, albeit other possibilities cannot be ruled out.

Reference: JENAM 2005: 'Distant Worlds': Workshop: Massive Stars and High-Energy Emission in OB Associations

Weblink: http://www.astro.physik.uni-potsdam.de/~ftp/oskinova/x-ray_ssc.ps

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Are WC9 Wolf-Rayet stars in colliding-wind binaries?

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We present results from a spectroscopic search for massive companions to dust-making Galactic WC9 stars as a step to testing the paradigm that dust formation in these systems requires colliding winds to produce over densities. We find evidence for OB companions to the WC9 stars WR 59 and WR 65, but not WR 121 or WR 117.

We identify lines of N III-IV and possibly N II in the spectrum of WR 88, one of the few Galactic WC9 stars which do not make circumstellar dust, and suggest that WR 88 is a transitional WN-WC9 object and less evolved than the other WC9 stars. On the other hand, the possible identification of a strong emission line at 4176A in the spectrum of WR 117 with Ne I suggests that this star is more evolved than other WC9 stars studied.

Reference: Contribution to: "Massive Stars and High-Energy Emission in OB Associations"; JENAM 2005, held in Liège (Belgium)

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Jobs

PhD Position in Theoretical Studies of Massive Stars in the Early Universe
University of Amsterdam

A 4-year PhD position is available immediately for theoretical research into the nature of massive stars in the early universe. The project is a collaboration between the astronomical institutes of Amsterdam (dr. de Koter and prof. Waters), Utrecht (prof. Langer), and Keele, England (dr. Vink). The PhD student will be based in Amsterdam, but regularly spend time in Utrecht and Keele as well.

The project aims at a comprehensive study of the evolution of very massive stars in the high-redshift universe, up to the supernova explosion, focusing in detail on the physics and interplay between the two dominant processes controlling this evolution, i.e. mass loss and rotation. The evolution of these low-metallicity massive stars is of key importance to understand the early evolution of the universe, including its re-ionization, galaxy formation, and chemical evolution of young galaxies and of the intra-galaxy medium. Gamma-ray bursts and hypernovae may end the lives of these massive objects, therefore these studies will have direct impact on our understanding of the nature of these explosive events.

The entire project comprises research for two PhD students, one dealing primarily with predictions of the mass loss properties of massive stars in the early universe, and one with the evolution of these stars, accounting for mass loss and rotation. Here we advertise the position focusing on predicting the mass loss properties, for which the successful candidate will perform numerical simulations using state-of-the-art models. Clearly, the two PhDs will work closely together.

The successful candidate must have a Masters degree in astronomy or theoretical physics. Applications should include a curriculum vitae (including a list of exam grades), a brief statement of research experience, and two letters of reference. Review of applications will begin on December 15th and continue until the position is filled. Salary will be on the standard Dutch university scale. The position is funded by The Netherlands Research School for Astronomy (NOVA), a national association of university astronomy departments.

The Astronomical Institute Anton Pannekoek is a lively research institute with about 10 faculty, 10 postdocs, and 20-25 PhD students, located within 20 minutes of downtown Amsterdam on a science campus that is the ICT center of the Netherlands.

Direct inquiries and applications to:

Dr. A. de Koter
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Postdoc on Exreme Mass Loss from SuperEddington Stars

Stan Owocki

Bartol Research Institute, Department of Physics and Astronomy, University of Delaware, Newark, DE 19716 USA

I am looking for a post-doc (or "research scientist") to work with me on developing models of instabilities and mass loss for massive stars near and above the Eddington limit, and/or to test such models against observations of LBV stars. The position is supported by a combination of NSF and NASA grants, and could last for up to 3 years.

A more complete description is given in the AAS job listing #22275, available via the AAS web page at aas.org. Further information is also available via the cited weblink below.

Inquiries and even electronic applications (names of 3 references, PDFs of vita and research statement, no later than Jan. 31, 2006) can be sent by email to the addresses given below.

Further information on the web at `http://www.bartol.udel.edu/ owocki/masslosspdsearch/`

General inquiries to `owocki@bartol.udel.edu`

Submit applications to `masslosspdsearch@bartol.udel.edu`

Mass Loss from Stars and the Evolution of Stellar Clusters

A conference to mark the retirement of Henny Lamers

May 29 - June 1, 2006
Lunteren, the Netherlands

www.astro.uu.nl/siu/workshop.html

Scope of the meeting

A 3.5 day scientific meeting will be held from May 29 to June 1st, 2006 to mark the 65th birthday of Professor Henny Lamers. The subject of the conference will be mass loss from stars and the evolution of stellar clusters, two topics where Henny has made fundamental contributions and that have clear connections. Mass loss from stars is a crucial physical process for the life and ultimate fate of stars with a wide range of initial mass. This stellar mass loss not only affects the lives of individual stars, but also of the clusters in which they live. This is particularly true for the most massive stars in galaxies. Stellar winds (and later supernovae) from massive stars in clusters combine to produce a cluster wind; the resulting mass loss can drive galactic-scale winds, and significantly affect the evolution of the cluster. Mass loss from clusters also results from the loss of cluster members through the dynamical evolution of the cluster and its interaction with the environment. The meeting will focus on the physics of mass loss from individual stars as well as from young stellar clusters, and on the implications of the mass loss process for the evolution of these systems.

Scientific Organizing Committee

Joe Cassinelli, Madison – Ed Churchwell, Madison – Alex de Koter, Amsterdam – Bruce Elmegreen, New York – Charlie Lada, Cambridge USA – Norbert Langer, Utrecht – Antonella Nota, Baltimore – Nino Panagia, Baltimore – Simon Portegies Zwart, Amsterdam – Linda Smith, London, (co-chair) – Rens Waters, Amsterdam, (co-chair)

Local Organizing Committee

Alex de Koter, Amsterdam (chair) – Sabina Chita, Utrecht – Selma de Mink, Utrecht – Sake Hogeveen, Utrecht – Remco Scheepmaker, Utrecht – Jacco Vink, Utrecht – Marion Wijburg, Utrecht – Ed van der Zalm, Utrecht

Time table of events

September 2005: 1st announcement
October 5, 2005: Early registration opens
February 2006: 2nd announcement
April 2006: Early registration closes
May 2006: 3rd and final announcement
May 29-June-1: Conference

The registration fee will be 250 Euro. Those interested in attending the meeting are kindly requested to fill in the preregistration form at the website of the meeting
http://www.astro.uu.nl/siu/lunteren/home.html/