THE HOT STAR NEWSLETTER

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and related phenomena in galaxies

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Wolf-Rayet bibliography maintained by Karel A. van der Hucht
ftp://ftp.sron.nl/pub/karelh/UPLOADS/WRBIB/

Contents of this newsletter

Working Group Matters

As a result of the recent elections, the following six colleagues will serve on the ORGANIZING COMMITTEE (OC) of the IAU Working Group on Hot Massive Stars:

Paul Crowther	Phil Massey
Gloria Koenigsberger	George Meynet
Claus Leitherer	Joachim Puls

They are thus joining the four members who remain on the OC: Henny Lamers, Tony Moffat, Stan Owocki, Philippe Eenens. We take this opportunity to thank *Joe Cassinelli, Peter Conti, Kathy Garmany, Rolf Kudristky, André Maeder and Karel van der Hucht* for their most valuable contribution and advice while they served on the OC.

Letter to the Editor

Enter WR 159 = BD+62°2296B = BCCS 1 (WN4)

When updating the VIth Catalogue of Galactic Wolf-Rayet Stars (van der Hucht *et al.* 1981) to the VIIth (van der Hucht 2001) with the help of available literature, their number increased from 156 to 227. However, at the time it should have been at least 228, because I overlooked at least one paper. And I would probably still not have been aware of this, had I not received a preprint from Ignacio Negueruela (2003, see *Hot Star Newsletter* No. 77) on the WR classification of BD+62°2296B, a visual companion to the B2.5Ia star BD+62°2296A in the region of the OB association Cas OB5.

A check in SIMBAD shows that almost a decade ago, in the *Bulletin of the Special Astrophysical Observatory*, the spectral discovery and WR classification of BD+62°2296B had been announced already by Bartaya, Chargeishvili, Chentsov & Shkhagosheva (1994) in their paper entitled 'Hypergiant 6 Cas and Association Cas OB5', a paper that I had overlooked. They reached the conclusion that BD+62°2296B is a Population I WN4 star, which now has been confirmed by Negueruela (2003). The discovery designation for this 'new' WR star is, therefore, BCCS 1.

The BD+62°2296ABC visual triple system was discovered in 1877 by E. baron Dembowski (1883). The Washington Double Star Catalogue (Mason, Wycoff & Hartkopf 2001) shows that in the time span 1877 - 1991 the separation of the visual pair AB changed from $1.''6$ to $1.''9$, and the position angle from to 359° to 357°.

While listing BD+62°2296A as a member of Cas OB5, Garmany & Stencel (1992) gave a distance modulus for that OB association of $DM = 11.5$ mag (Humphreys 1978 gave $DM = 12.0$) and an average visual extinction of $E_{B-V} = 0.75 \pm 0.16$, corresponding to $A_V = 2.3 \pm 0.5$, or $A_v = 2.6 \pm 0.5$ in the photometric system of Smith (1968). The colours of the B2.5Ia supergiant BD+62°2296A indicate that the extinction is larger than the average given for Cas OB5, possible related to the nearby dark foreground cloud LDN 1252 (Negueruela, priv. comm). This, together with an absolute visual magnitude for WN4 stars of $M_v = -3.5$ mag (van der Hucht 2001), implies an apparent magnitude $v \geq 10.6 \pm 0.5$ for the WN4 component BD+62°2296B. This is consistent with the Tycho magnitude $V_{\rm T} = 11.2$, quoted in the WDS for BD+62°2296B. We summarize some basic parameters for WR 159.

Table 1: Parameters for WR 159

designations	WR 159, BD+62°2296B, BCCS 1
RA, Dec (J2000, Tycho)	23 47 20.4, +63 13 14
$V_{\rm T}$	11.2 mag
spectral type	WN4
d, if member of Cas OB5	2 - 2.5 kpc

We do welcome the (not-so-) newly discovered Galactic WN4 star BD+62°2296B as WR 159, and wish it proper attention by the WR pundits community.

Acknowledgement. I am much indebted to Ignacio Negueruela for sending me his preprint, and to Bill Hartkopf and Brian Mason, keepers of the invaluable Washington Double Star Catalogue maintained at the U.S. Naval Observatory, for providing information on the visual multiple nature of BD+62°2296.

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Karel A. van der Hucht, Utrecht, July 2003

News

The Final of NASA's Great Observatories Successfully Launched into Orbit

Announcement submitted by Pat Morris

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The Space Infrared Telescope Facility, the final mission in NASA's Great Observatories Program and a part of NASA's Origins Program, was successfully launched into solar orbit on a Delta II rocket from Kennedy Space Center on 25 August 2003. SIRTF is on a 2.5 year mission to carry out infrared observations over the 3 to 180 μm range with its InfraRed Array Camera (IRAC), Multiband Imaging Photometer for SIRTF (MIPS), and InfraRed Spectrograph (IRS). The observatory is currently in the early stages of its 90-day checkout phase, and will commence at the end of the checkout (in early December 2003) with Galactic and Extragalactic First Look Surveys using the IRAC and MIPS. Legacy Program and Guaranteed Time Observations will follow the surveys. Of interest to the Hot Star community, the Legacy and GTO programs include spectroscopy and imaging of hot massive stars and their circumstellar environments, regions of massive star birth, giant HII regions, starburst galaxies, ULIRGs and active galaxies at high redshift. Further opportunities in these and related areas are offered through the SIRTF Guest Observer program, with some 3700 hours of observing time expected to be available in Cycle 1. Proposals for this Cycle will be due in mid-February 2004, but the schedule in the Call for Proposals issued by the SIRTF Science Center (SSC) will be updated in December 2003, at the end of the checkout phase.

For more information about SIRTF, its science capabilities, the Legacy and Guaranteed Time programs, and the Guest Observer Program and schedule, go to `http://sirtf.caltech.edu`, or drop a note to your local Hot Star pundit at the SSC.

Obituary

ANNE BARBARA UNDERHILL (1920-2003)[1]

Donald C. Morton

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On July 3 of this year Canada lost a distinguished astrophysicist with the passing of Dr. Anne Barbara Underhill. She is remembered for her many contributions, both theoretical and observational, to our knowledge of hot stars, and for her spirited comments at colloquia and symposia.

Anne was born in 1920 on June 12 in Vancouver. There she attended UBC and obtained an honours BA in Physics and Chemistry in 1942 and an MA in Physics and Mathematics in 1944. From 1946 to 1948 she was a PhD student at the Yerkes Observatory of the University of Chicago, working with Chandrasekhar during his Radiative Transfer years. While there she also learned much about stellar spectra from Otto Struve and Jesse Greenstein. Following a post-doctoral fellowship with Bengt Strömgren at the Copenhagen Observatory, Anne accepted a research position at the Dominion Astrophysical Observatory in Victoria in 1949. In 1962 she moved to the Netherlands as a full professor at the University of Utrecht, where she guided many students into productive careers. She became Chief of the Laboratory of Optical Astronomy at the NASA Goddard Space Flight Center in Maryland in 1970. There she also was Project Scientist for the very successful International Ultraviolet Explorer during its development. From 1977 to 1985, as a Senior Scientist at Goddard, she continued her research and book writing and editing. She retired to Vancouver with an honorary professorship at UBC and visited the DAO for observing, often with students. York University gave her an honorary degree in 1969 and UBC did so in 1992.

The Royal Society of Canada elected her a fellow in 1985. The same year the Canadian Astronomical Society gave her the C. S. Beals Award in recognition of her outstanding achievements in research.

Anne was a pioneer as a woman astrophysicist, contributing important theoretical results in her early work, as well as her better known observational studies. Her theoretical 1947 paper on "Absorption Lines Formed in a Moving Atmosphere" in ApJ 106, 128 could have been her thesis. Without the help of electronic computers, she began calculating model atmospheres of O-type stars (1950, Publ Copenhagen Obs. #151; 1951, Publ. DAO 8, 357). My first contact with Anne was to use her 1957 models of B1.5 and B2.5 main sequence stars (Publ. DAO 10, 57) to calibrate the H-R diagram in a paper I wrote in 1958 on the carbon cycle while a graduate student in Princeton. In 1960 she programmed the computer at the Princeton Institute for Advanced Study to calculate model atmospheres.

Our common interest in hot stars resulted in frequent correspondence and much helpful advice from Anne. We published two joint papers on the far-UV spectra of stars. She had a marvelous familiarity with the relevant literature. When I discovered the high-velocity far-UV mass loss from the Orion supergiants in 1965, she told me about the puzzling ground-based observations of very broad emission lines in similar stars by Robert Wilson (1958, Publ. Roy. Obs. Edinburgh 2, 61).

Anne had many interests outside of astronomy, including hiking, bird watching, singing in church choirs, and Girl Guides. During her Victoria years she did not observe on Monday nights because that was the night she led a Guide troop at St. John's Anglican Church, where she also sang in the choir.

[1]This article originally appeared in the Autumnal Equinox 2003 edition of *Cassiopeia*, the newsletter of the Canadian Astronomical Society / Société Canadienne d'Astronomie.

In gathering information about Anne, I discovered an interesting detail of Canadian history. Her Uncle James T. Underhill led the survey team in 1927 that measured the height of 13,260 ft. (4042 m) for the recently discovered Mystery Mountain – later named Mt. Waddington. Thus this peak, only 285 km northwest of Vancouver, is higher than Mt. Robson and the highest peak in Canada south of the arctic regions.

Nancy Roman and Dan Collier have prepared excellent reviews of Anne's life for the Bulletin of the American Astronomical Society and the Journal of the Royal Astronomical Society of Canada respectively.[2]

Accepted Papers

Stellar evolution with rotation and magnetic fields: I. The relative importance of rotational and magnetic effects

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We compare the current effects of rotation in stellar evolution to those of the magnetic field created by the Tayler instability. In stellar regions, where magnetic field can be generated by the dynamo due to differential rotation (Spruit 2002), we find that the growth rate of the magnetic instability is much faster than for the thermal instability. Thus, meridional circulation is negligible with respect to the magnetic fields, both for the transport of angular momentum and of chemical elements. Also, the horizontal coupling by the magnetic field, which reaches values of a few 10^5 G, is much more important than the effects of the horizontal turbulence. The field, however, is not sufficient to distort the shape of the equipotentials. We impose the condition that the energy of the magnetic field created by the Tayler–Spruit dynamo cannot be larger than the energy excess present in the differential rotation. This leads to a criterion for the existence of the magnetic field in stellar interiors.

Numerical tests are made in a rotating star model of 15 $M_\odot$ rotating with an initial velocity of 300 km$\cdot$s^{-1}. We find that the coefficients of diffusion for the transport of angular momentum by the magnetic field are several orders of magnitude larger than the transport coefficients for meridional circulation and shear mixing. The same applies to the diffusion coefficients for the chemical elements, however very close to the core, the strong μ–gradient reduces the mixing by the magnetic instability to values not too different from the case without magnetic field. We also find that magnetic instability is present throughout the radiative envelope, with the exception of the very outer layers, where differential rotation is insufficient to build the field, a fact consistent with the lack of evidence of strong fields at the surface of massive stars.

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on the web at http://arXiv.org/abs/astro-ph/0309672

[2]Editor's Note: Allan Willis has also prepared an obituary for *Astronomy & Geophysics, The Journal of the Royal Astronomical Society.*

The LBV nature of Romano's star (GR 290) in M 33

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We report the first spectroscopic study of the LBV candidate GR 290 in M 33 ("Romano's star") taken in February 2003, showing, besides prominent hydrogen and He I emission lines, the 4630–60 Å blend and a weak He II 4686 Å emission typical of Of stars. Our broad–band photometry shows that the star was observed during a phase of minimum optical luminosity, with B=17.91±0.03, and a slightly positive colour index, which we tentatively attribute to an anomalous continuum energy distribution. We argue that GR 290 is indeed an LBV star presently in a high temperature phase, that should be followed – also in a short time – by ample spectroscopic and associated photometric variations.

Accepted by Astronomy & Astrophysics

Preprints from `polcaro@rm.iasf.cnr.it`

or by anonymous ftp to `ftp.rm.iasf.cnr.it/uvspace/GR290.ps`

or on the web at `ftp://ftp.rm.iasf.cnr.it/uvspace/GR290.ps`

A Study of Cyg OB2: Pointing the Way Towards Finding Our Galaxy's Super Star Clusters

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New optical MK classification spectra have been obtained for 14 OB star candidates identified by Comerón et al. (2002) and presumed to be possible members of the Cyg OB2 cluster as recently described by Knödlseder (2000). All 14 candidate OB stars observed are indeed early-type stars, strongly suggesting the remaining 31 candidates by Comerón et al. are also early-type stars. A thorough investigation of the properties of these new candidate members compared to the properties of the Cyg OB2 cluster star have been completed, using traditional as well as newly revised effective temperature scales for O stars. The cooler O-star, effective temperature scale of Martins et al. (2002) gives a very close distance for the cluster (DM = 10.4). However, even using traditional effective temperature scales, Cyg OB2 appears to be slightly closer (DM = 10.8) than previous studies determined (DM = 11.2; Massey & Thompson 1992), when the very young age of the stellar cluster ($\sim$ 2 x 10^6 yrs) is taken into account in fitting the late-O and early-B dwarfs to model isochrones. Of the 14 new OB stars observed for this study, as many as half appear to be significantly older than the previously studied optical cluster, making their membership in Cyg OB2 suspect. So, while some of the newly identified OB stars may represent a more extended halo of the Cyg OB2 cluster, the survey of Comerón et al. also picked up a large fraction of non-members. Presently, estimates of the very high mass of this cluster ($M_{cl} \approx 10^4 M_\odot$ and over 100 O stars) first made by Knödlseder (2000) remain higher than this study can support. Despite this, the recognition of Cyg OB2 being a more massive and extensive star cluster than previously realized using 2MASS images, along with the recently recognized candidate super star cluster Westerlund 1 only a few kpc away (Clark & Negueruela 2002), reminds us that we are woefully under-informed about the massive cluster population in our Galaxy. Extrapolations of

the locally derived cluster luminosity function indicate 10s to perhaps 100 of these very massive open clusters ($M_{cl} \approx 10^4 M_\odot$, $M_V \approx -11$) should exist within our galaxy. Radio surveys will not detect these massive clusters if they are more than a few million years old. Our best hope for remedying this shortfall is through deep infrared searches and follow up near-infrared spectroscopic observations, as was used by Comeron et al. (2002) to identify candidate members of the Cyg OB2 association.

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Preprints on the web at `www.physics.uc.edu/~hanson/ABSTRACTS/hanson13.html`

Massive Stars in the Local Group: Inplications for Stellar Evolution and Star Formation

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The galaxies of the Local Group serve as important laboratories for understanding the physics of massive stars. Here I discuss what is involved in identifying various kinds of massive stars in nearby galaxies: the hydrogen-burning O-type stars, and their evolved He-burning evolutionary descendants, the luminous blue variables, red supergiants, and Wolf-Rayet stars. Primarily I review what our knowledge of the massive star population in nearby galaxies has taught us about stellar evolution and star formation. I show that the current generation of stellar evolutionary models do well at matching some of the observed features, and provide a look at the sort of new observational data that will provide a benchmark against which new models can be evaluated.

Accepted by Annual Reviews Astronomy & Astrophysics
Preprints from `ftp://ftp.lowell.edu/pub/massey/annualmassey.pdf`

The Discovery of a Twelfth Wolf-Rayet Star in the Small Magellanic Cloud

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We report the discovery of a relatively faint ($V = 15.5$) early-type WN star in the SMC. The line strength and width of He II $\lambda4686$ emission is similar to that of the other SMC WNs, and the presense of N V $\lambda4603, 19$ emission (coupled with the lack of N III) suggests this star is of spectral type WN3-4.5, and thus is similar in type to the other SMC WRs. Also like the other SMC WN stars, an early-type absorption spectrum is weakly present. The absolute magnitude is comparable to that of other (single) Galactic early-type WNs. The star is located in the Hodge 53 OB association, which is also the home of two other SMC WNs. This star, which we designate SMC-WR12, was actually detected at a high significance level in an earlier interference-filter survey, but the wrong star was observed as part of a spectroscopic followup, and this case of mistaken identity resulted in its Wolf-Rayet nature not being recognized until now.

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Preprints from `ftp://ftp.lowell.edu/pub/massey/smcwr12.ps.gz`

The Evolution of Massive Stars. I. Red Supergiants in the Magellanic Clouds

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We investigate the red supergiant (RSG) content of the SMC and LMC using multi-object spectroscopy on a sample of red stars previously identified by *BVR* CCD photometry. We obtained high accuracy (< 1 km s^{-1}) radial velocities for 118 red stars seen towards the SMC and 167 red stars seen towards the LMC, confirming most of these (89% and 95%, respectively) as red supergiants (RSGs). Spectral types were also determined for most of these RSGs. We find that the distribution of spectral types is skewed towards earlier type at lower metallicities: the average (median) spectral type is K5-7 I in the SMC, M1 I in the LMC, and M2 I in the Milky Way. Our examination of the Kurucz Atlas 9 model atmospheres suggests that the effect that metallicity has on the appearance on the TiO lines is probably sufficient to account for this effect, and we argue that RSGs in the Magellanic Clouds are 100°K (LMC) and 300°K (SMC) cooler than Galactic stars of the same spectral types. The colors of the Kurucz models are not consistent with this interpretation for the SMC, although other models (e.g., Bessel et al.) show good agreement. A finer grid of higher-resolution synthetic spectra appropriate to cool supergiants is needed to better determine the effective temperature scale. We compare the distribution of RSGs in the H-R diagram to that of various stellar evolutionary models; we find that none of the models produce RSGs as cool and luminous as what is actually observed. This result is much larger than any uncertainty in the effective temperature scale. We note that were we to simply adopt the uncorrected Galactic effective scale for RSGs and apply this to our sample, then the SMC's RSGs would be under luminous compared to the LMC's, contrary to what we expect from stellar evolution considerations. In all of our H-R diagrams, however, there is an elegant sequence of decreasing effective temperatures with increasing luminosities; explaining this will be an important test of future stellar evolutionary models. Finally, we compute the blue-to-red supergiant ratio in the SMC and LMC, finding that the values are indistinguishable (~ 15) for the two Clouds. We emphasize that "observed" B/R values must be carefully determined if a comparison to that predicted by stellar models is to be meaningful. The non-rotation Geneva models overestimate the number of blue-to-red supergiants for the SMC, but underestimate it for the LMC; however, given the inability to produce high luminosity RSGs in the models that match what is observed in the H-R diagram, such a disagreement is not surprising.

Accepted by AJ

Preprints from `ftp://ftp.lowell.edu/pub/massey/rsgs.ps.gz`

Gemini Mid-Infrared Imaging of Massive Young Stellar Objects in NGC 3576

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We present a mid-infrared study of NGC 3576. The high-resolution images were taken at the Gemini South Observatory through narrow and broad band filters centered between 7.9 μm and 18 μm.

The nearly diffraction limited images show IRS 1 resolved into 4 sources for the first time in the 10 μm band. The positions of the sources are coincident with massive young stellar objects detected previously in the near infrared. The properties of each object, such as spectral energy distribution, silicate absorption feature, color temperature and luminosities were obtained and are discussed. We also report observations of two other YSO candidates and the detection of a new diffuse MIR source without a NIR counterpart. We conclude that none of these sources contributes significantly to the ionization of the HII region. A possible location for the ionization source of NGC 3576 is suggested based on both radio and infrared data.

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or on the web at `astro-ph/0308180 (low-res)`

Hot Gas in the Circumstellar Bubble S308

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S 308 is a circumstellar bubble blown by the WN4 star HD 50896. It is one of the only two single-star bubbles that show detectable diffuse X-ray emission. We have obtained *XMM-Newton* EPIC observations of the northwest quadrant of S 308. The diffuse X-ray emission shows a limb-brightened morphology, with a clear gap extending from the outer edge of the diffuse X-ray emission to the outer rim of the nebular shell. The X-ray spectrum of the diffuse emission is very soft, and is well fitted by an optically thin plasma model for a N-enriched plasma at temperatures of $\sim 1.1 \times 10^6$ K. A hotter gas component may exist but its temperature is not well constrained as it contributes less than 6% of the observed X-ray flux. The total X-ray luminosity of S 308, extrapolated from the bright northwest quadrant, is $\leq (1.2 \pm 0.5) \times 10^{34}$ ergs s^{-1}. We have used the observed bubble dynamics and the physical parameters of the hot interior gas of S 308 in conjunction with the circumstellar bubble model of García-Segura & Mac Low (1995) to demonstrate that the X-ray-emitting gas must be dominated by mixed-in nebular material.

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or on the web at `http://xxx.lanl.gov/abs/astro-ph/0309192`

The central star of the planetary nebula N 66 in the Large Magellanic Cloud: A detailed analysis of its dramatic evolution 1983 – 2000

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The central star of the planetary nebula N 66 (alias WS 35, SMP 83 and HV 5967) in the Large Magel-

lanic Cloud enhanced its brightness dramatically in 1993 and 1994. Within the subsequent four years it returned to the previous level. Its spectrum resembles that of a Wolf-Rayet star of the nitrogen sequence (WN4.5). We monitored the object intensively from ground and with the Hubble Space Telescope. Now we present the complete set of spectroscopic observations from the different epochs before, during and after the brightness outburst of N 66. The stellar spectra from the different epochs are analyzed in detail by means of most advanced non-LTE models for expanding stellar atmospheres. The main results are: the luminosity, $\log L/L_{\odot} = 4.6$, before and after the outburst is exceptionally high for a central star of a planetary nebula. During the outburst in 1994, it even climbed up to $\log L/L_{\odot} = 5.4$ for about one year. The effective temperature of about 112 kK remained roughly constant, i.e. the luminosity mainly increased because of a larger effective stellar radius. The mass loss rate increased from $10^{-5.7} M_{\odot} \mathrm{yr}^{-1}$ in the quiet state to $10^{-5.0} M_{\odot} \mathrm{yr}^{-1}$ during the outburst. The chemical composition of the stellar atmosphere is that of incompletely CNO-processed matter: it is dominated by helium with a rest of hydrogen, nitrogen being slightly enhanced and carbon strongly depleted. We extensively discuss possible scenarios for the nature and evolutionary origin of N 66, which should explain the exceptional stellar parameters, the atmospheric composition, the outburst mechanism, and the existence of the bipolar nebula which was ejected only a few thousand years ago and contains about 0.6 solar masses of hydrogen-rich matter. If being a single star, N 66 might be (i) a low-mass star after the Asymptotic Giant Branch, as usually adopted for central stars of planetary nebulae, (ii) a massive, i.e. non-degenerate star, or (iii) a merger produced from two white dwarfs. Although there are no direct indications for binarity, we alternatively discuss whether N 66 might be (iv) a massive star which lost its hydrogen envelope in a recent common-envelope phase with a less massive companion, or (v) a white dwarf accreting mass from a companion with a high rate. None of the scenarios is free of any contradiction to at least one of the observational facts. However, the binary scenarios pose less severe problems. If N 66 is a white dwarf accreting matter in a close-binary system, its present accretion rate would bring it to the Chandrasekhar limit within a few hundred thousand years. Thus N 66 might be a candidate for a future type Ia supernova explosion in our cosmic neighborhood.

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Bright OB stars in the Galaxy I. Mass-loss and wind-momentum rates of O-type stars: A pure H alpha analysis accounting for line-blanketing

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We study mass-loss and wind momentum rates of 29 Galactic O-type stars with luminosity classes I, III and V by means of a pure H alpha profile analysis and investigate to what extent the results compare to those originating from a state-of-the-art, complete spectral analysis. Our investigation relies on the approximate method developed by Puls et al. (1996, A&A, 305, 171) which we have modified

to account for the effects of line-blanketing. Effective temperatures and gravities needed to obtain *quantitative* results from such a simplified approach have been derived by means of calibrations based on most recent spectroscopic NLTE analyses and models of Galactic stars by Repolust et al. (2003, A&A, accepted) and Martins et al. (2002, A&A, 382, 999). Comparing (i) the derived wind-densities to those determined by Repolust et al. for eleven stars in common and (ii) the Wind-momentum Luminosity Relationship (WLR) for our sample stars to those derived by other investigations, we conclude that our approximate approach is actually able to provide consistent results. Additionally, we studied the consequences of "fine tuning" some of the direct and indirect parameters entering the WLR, especially by accounting for different possible values of stellar reddening and distances. Combining our data set with the corresponding data provided by Herrero et al. 2002, A&A, 396, 949) and Repolust et al. we finally study the WLR for the largest sample of Galactic O-type stars gathered so far, including an elaborate error treatment. The established disagreement between the theoretical predictions and the "observed" WLRs being a function of luminosity class is suggested to be a result of wind clumping. Different strategies to check this hypothesis are discussed, particularly by comparing the H alpha mass-loss rates with the ones derived from radio observations.

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Preprints from `rozhen@mbox.digsys.bg`

The stellar environment of SMC N81

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We present near infrared *JHK* imaging of the Small Magellanic Cloud compact H II region N81 using the ISAAC camera at the ESO Very Large Telescope (Antu). Our analysis of the stellar environment of this young massive star region reveals the presence of three new stellar populations in the surrounding field which are mainly composed of low mass stars. The main population is best fitted by evolutionary models for $\sim 2\,M_\odot$ stars with an age of 1 Gyr. We argue that these populations are not physically associated with the H II region N81. Instead they are the result of a number of low mass star forming events through the depth of the SMC south of its Shapley's wing. The populations can rather easily be probed due to the low interstellar extinction in that direction.

Accepted by Astronomy & Astrophysics
Preprints from `Frederic.Meynadier@obspm.fr`
or on the web at `http://www.arxiv.org/abs/astro-ph/0309126`

Shocked gas layers surrounding the WR nebula NGC 2359

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NGC 2359 is a Wolf-Rayet (W-R) nebula partially bound by a rather dense and warm molecular cloud. We present the results derived from CO and ^{13}CO fully sampled maps of the molecular material with angular resolutions up to 12*arcsec*. We have detected three different velocity components, and determined their spatial distribution and physical properties. The kinematics, morphology, mass and density are clearly stratified with respect to the W-R star. These features allow us to learn about the recent evolutionary history of WR 7, because the multiple layers could be associated to several energetic events which have acted upon the surrounding circumstellar medium. Hence, a careful study of the different shockfronts contain clues in determining the present and past interaction of this evolved massive star with its surroundings. ¿From the analysis of the mass-loss history in massive stars like WR 7, we suggest that the multiple layers of shocked molecular gas are likely to be produced during the earlier LBV phase and/or the actual W-R stage of WR 7.

Accepted by Astronomy & Astrophysics

Preprints from `jricardo.rizzo@fis.cie.uem.es`
or on the web at `astro-ph/0308527`

High-Resolution *Chandra* Spectroscopy of γ Cassiopeia (B0.5e)

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γ Cas is the prototypical classical B0.5e star and is now known to be the primary in a wide binary system. It has long been famous for its unique hard X-ray characteristics, among which are variations that correlate with changes in a number of optical light and UV-line and continuum properties. These peculiarities have led to a picture in which processes on or near the Be star produce the observed X-ray emission. In this paper we report on a 53 ks *Chandra* HETGS observation of this target.

An inspection of our spectrum shows that it is quite atypical for a massive star. The emission lines appear “weak” because of a strong short-wavelength continuum that arises from a hot plasma with kT = 11 − 12 keV. The spectrum exhibits many lines, the strongest of which are Lyα features of H-like species from Fe through the even-Z, intermediate elements (S, Si, Mg, Ne) down to O and N. Line ratios of the “rif triplet” for a variety of He-like ions and of Fe XVII are consistent with the dominance of collisional atomic processes. However, the presence of Fe and Si fluorescence K features indicates that photoionization also occurs in nearby cold gas. The line profiles indicate a mean velocity at rest with a r.m.s. line broadening of 500 km s^{-1} and little or no asymmetry. An

empirical global fitting analysis of the line and continuum spectrum suggests that there are actually 3–4 plasma emission components. The first is the dominant hot (12 keV) component, of which some fraction ($10-30\%$) is heavily absorbed, while the remainder is affected by only a much lower column density of 3×10^{21} cm^{-2}. The hot component has a Fe abundance of only $0.22\pm.05$ solar. The other two or three major emission components are "warm" and are responsible for most other emission lines. These components are dominated by plasma having temperatures near 0.1, 0.4, and 3 keV. Altogether, the warm components have an emission measure of about 14% of the hot component, a low column density, and a more nearly solar composition. The 100 eV component is consistent with X-ray temperatures associated with a wind in a typical early B star. Nonetheless, its emission measure is a few times higher than would be expected by this explanation. The strength of the fluorescence features and the dual-column absorption model for the hot plasma component suggest the presence near the hot sites of a cold gas structure with a column density of $\sim 10^{23}$ cm^{-2}. Because this is also the value determined by Millar & Marlborough for the vertical column of the Be disk of γ Cas, these attributes suggest that the X-ray emitting sources could be close to the disk and hence the Be star. Finally, we discuss the probably related issues of the origin of the warm emission components as well as the puzzling deficient Fe abundance in the hot component. It is possible that the latter anomaly is related to the FIP (abundance fractionation) effect found in certain coronal structures on the Sun and RS CVn stars. This would be yet another indication that the X-rays are produced in the immediate vicinity of the Be star.

Accepted by Ap.J., to appear January 10, 2004

Preprints from msmith@stsci.edu

or on the web at http://astro.swarthmore.edu/~cohen/Papers/gcas.ps or .pdf

Inference of hot star density stream properties from data on rotationally recurrent DACs

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The information content of data on rotationally periodic recurrent discrete absorption components (DACs) in hot star wind emission lines is discussed. The data comprises optical depths $\tau(w,\phi)$ as a function of dimensionless Doppler velocity $w = (\Delta\lambda/\lambda_0)(c/v_\infty)$ and of time expressed in terms of stellar rotation angle ϕ. This is used to study the spatial distributions of density, radial and rotational velocities, and ionisation structures of the corotating wind streams to which recurrent DACs are conventionally attributed.

The simplifying assumptions made to reduce the degrees of freedom in such structure distribution functions to match those in the DAC data are discussed and the problem then posed in terms of a bivariate relationship between $\tau(w,\phi)$ and the radial velocity $v_{\rm r}(r)$, transverse rotation rate $\Omega(r)$ and density $\rho(r,\phi)$ structures of the streams. The discussion applies to cases where: the streams are equatorial; the system is seen edge on; the ionisation structure is approximated as uniform; the radial

and transverse velocities are taken to be functions only of radial distance but the stream density is allowed to vary with azimuth. The last kinematic assumption essentially ignores the dynamical feedback of density on velocity and the relationship of this to fully dynamical models is discussed. The case of narrow streams is first considered, noting the result of Hamann et al (2001) that the apparent acceleration of a narrow stream DAC is *higher* than the acceleration of the matter itself, so that the apparent slow acceleration of DACs cannot be attributed to the slowness of stellar rotation. Thus DACs either involve matter which accelerates slower than the general wind flow, or they are formed by structures which are not advected with the matter flow but propagate upstream (such as Abbott waves). It is then shown how, in the kinematic model approximation, the radial speed of the absorbing matter can be found by inversion of the apparent acceleration of the narrow DAC, for a given rotation law.

The case of broad streams is more complex but also more informative. The observed $\tau(w, \phi)$ is governed not only by $v_\mathrm{r}(r)$ and $\Omega(r)$ of the absorbing stream matter but also by the density profile across the stream, determined by the azimuthal (ϕ_0) distribution function $F_0(\phi_0)$ of mass loss rate around the stellar equator. When $F_0(\phi_0)$ is fairly wide in ϕ_0, the acceleration of the DAC peak $\tau(w, \phi)$ in w is generally slow compared with that of a narrow stream DAC and the information on $v_\mathrm{r}(r)$, $\Omega(r)$ and $F_0(\phi_0)$ is convoluted in the data $\tau(w, \phi)$.

We show that it is possible, in this kinematic model, to recover by inversion, complete information on all three distribution functions $v_\mathrm{r}(r)$, $\Omega(r)$ and $F_0(\phi_0)$ from data on $\tau(w, \phi)$ of sufficiently high precision and resolution since $v_\mathrm{r}(r)$ and $\Omega(r)$ occur in combination rather than independently in the equations. This is demonstrated for simulated data, including noise effects, and is discussed in relation to real data and to fully hydrodynamic models.

Accepted by Astronomy and Astrophysics
Preprints from `richard@astro.gla.ac.uk`
or on the web at
`http://www.astro.gla.ac.uk/~richard/windpap/Wind_Paper1_final_allfigures.ps.gz`

Submitted Papers

The Effect of Magnetic Field Tilt and Divergence on the Mass Flux and Flow Speed in a Line-Driven Stellar Wind

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We carry out an extended analytic study of how the tilt and faster-than-radial expansion from a magnetic field affect the mass flux and flow speed of a line-driven stellar wind. A key motivation is to reconcile results of numerical MHD simulations with previous analyses that had predicted non-spherical expansion would lead to a strong speed enhancement. By including finite-disk correction effects, a dynamically more consistent form for the non-spherical expansion, and a moderate value of the line-driving power index α, we infer more modest speed enhancements that are in good quantitative agreement with MHD simulations, and also are more consistent with observational results. Our analysis also explains simulation results that show the latitudinal variation of the surface mass flux scales with the square of the cosine of the local tilt angle between the magnetic field and the radial

direction. Finally, we present a perturbation analysis of the effects of a finite gas pressure on the wind mass loss rate and flow speed in both spherical and magnetic wind models, showing that these scale with the ratio of the sound speed to surface escape speed, a/v_{esc}, and are typically 10-20% compared to an idealized, zero-gas-pressure model.

Submitted to Astrophysical Journal
Preprints from `owocki@bartol.udel.edu`
or on the web at `www.bartol.udel.edu/∼owocki/preprints/btiltdiv-mdotvinf.pdf`

The effect of the process of star formation on the temporal evolution of the WR and O-type star populations in the Solar Neighbourhood

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A comparison between the observed O-type star and the WR star populations and the theoretically predicted ones depends on the effects of stellar wind mass loss during various phases and rotation on stellar evolution and, last not least, on the effects of binaries. Obviously, both populations depend on the massive star formation rate. In the present paper we show that the rate in the Solar Neighbourhood is fluctuating on a timescale which is smaller than the evolutionary timescale of a massive star. We demonstrate that this fluctuating behaviour affects both population enormously, in such a way that a comparison between observations and theoretical prediction to test stellar evolutionary models is ambiguous.

Submitted to Astron. & Astrophys.
or on the web at `astro-ph/0309104`

In Proceedings

Massive Young Clusters in the Local Group

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We analyze the properties of the Massive Young Clusters in the Local Group, concentrating on the youngest segment of this population and, more specifically, on the two best studied cases: 30 Doradus and NGC 604. 30 Doradus is a Super Star Cluster and will likely evolve to become a Globular Cluster in the future. NGC 604, on the other hand, is a Scaled OB Association that will be torn apart by the tidal effects of its host galaxy, M33. Given their extreme youth, both clusters are surrounded by a Giant H II Region produced by the high ionizing fluxes from O and WR stars. The two Giant H II Regions are found out to be rather thin structures located in the surface of Giant Molecular Clouds and their geometry turns out to be not too different from that of classical H II regions such as the Orion or Eagle nebulae.

To appear in: The Local Group as an Astrophysical Laboratory, STScI May 2003 Workshop
Preprints from: `http://www.stsci.edu/~jmaiz`

Massive Stars in the Local Group: Star Formation and Stellar Evolution

Philip Massey[1]

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The galaxies of the Local Group that are currently forming stars can serve as our laboratories for understanding star formation and the evolution of massive stars. In this talk I will summarize what I think we've learned about these topics over the past few decades of research, and briefly mention what I think needs to happen next.

To appear in The Local Group as an Astrophysical Laboratory, 2003 STScI May Symposium, eds. M. Livio et al.
Preprints from ftp://ftp.lowell.edu/pub/massey/masseymay.ps

Pre-suprenova evolution of rotating massive stars

Raphael Hirschi[1], **Georges Meynet**[1], **André Maeder**[1], **and Stéphane Goriely**[2]

[1] Observatoire de Genève,CH–1290 Sauverny, Switzerland
[2] Université Libre de Bruxelles, Bruxelles, Belgique

The Geneva evolutionary code has been modified to study the advanced stages (Ne, O, Si burnings) of rotating massive stars. Here we present the results of four 20 solar mass stars at solar metallicity with initial rotational velocities of 0, 100, 200 and 300 km/s in order to show the crucial role of rotation in stellar evolution. As already known, rotation increases mass loss and core masses (Meynet and Maeder 2000). A fast rotating 20 solar mass star has the same central evolution as a non-rotating 26 solar mass star. Rotation also increases strongly net total metal yields. Furthermore, rotation changes the SN type so that more SNIb are predicted (see Meynet and Maeder 2003 and N. Prantzos and S. Boissier 2003). Finally, SN1987A-like supernovae progenitor colour can be explained in a single rotating star scenario.

Submitted to the proceedings of IAU Colloquium 192, "Supernovae (10 years of 1993J)", Valencia, Spain 22-26 April 2003, eds. J.M. Marcaide, K.W. Weiler
Preprints from `raphael.hirschi@obs.unige.ch`
or on the web at `http://obswww.unige.ch/~hirschi/workd/valencia03.ps.gz`

Theses

Understanding the X-Ray Spectra of Early-Type Stars

Nathan A. Miller[1]

[1] University of Wisconsin-Eau Claire

The jump in X-ray spectral resolution made possible by the orbiting X-ray observatory *Chandra* has inspired a host of new techniques for determining the locations, motions, and temperature structures of the X-ray emitting plasma of hot stars. Although steady-state models of stellar winds are relatively well developed, X-rays offer a unique window on small-scale inhomogeneous structures in hot star winds. Currently, the most viable theory of X-ray generation in hot stars relies on small instabilities growing into X-ray emitting shocks distributed throughout the wind. The advent of high-resolution X-ray data allow many new ways to test this paradigm which are applied here.

In a detailed study of the O4f star ζ Pup, X-ray emitting gas is found extremely close to the photosphere, a region where it would be difficult to generate strong shocks. The X-ray line profiles of ζ Pup do conform well to what would be expected from an X-ray source embedded in an expanding, absorbing wind: they are broad due to the wind expansion, and their centroids are blue-shifted due to wind absorption of X-rays originating on the far side of the wind. Achieving an understanding of the line profiles of the O9III star δ Ori is not as straightforward, however. The emission lines are surprisingly narrow and do not show the expected blueshift. Detailed comparisons to theories of line profile generation are not able to resolve this discrepancy.

A study of the six normal hot stars observed with *Chandra* reveals that the good agreement found between the line profiles of ζ Pup and theoretical expectations is the exception, not the rule. Perhaps most puzzling, the X-ray line profiles of the two B stars studied are broadened by less than a couple of hundred $\mathrm{km\,s^{-1}}$, making it difficult to imagine how the X-ray emitting gas can be related in any way to the rapid outflow of the wind as a whole. A recently proposed infalling clump model for τ Sco can explain nearly all of its X-ray properties. This model probably does not explain all B star X-ray emission, for the other B star studied (β Cru) is a much dimmer and softer X-ray emitter.

Dissertation completed at the University of Wisconsin–Madison under the direction of Joseph P. Cassinelli

Preprints from `millerna@uwec.edu`
or on the web at `www.uwec.edu/millerna`

Jobs

Postdoctoral Research Associate at Lowell Observatory

Applications are invited for a postdoctoral position to work with Dr. Sally Oey at Lowell Observatory. The successful candidate will collaborate on research topics including galactic chemical evolution with respect to stellar populations and/or gas-phase element abundances. There will also be broad opportunity in the area of galactic and cosmic evolution with relation to feedback mechanisms from massive stars, namely: chemical evolution, radiative feedback (HII regions and diffuse, warm ionized medium), mechanical feedback, and/or global star formation processes and history. There will be opportunity to pursue independent research projects, and access to the Lowell Observatory telescope facilities.

The position is available for three years, with a flexible start date to begin during 2004. Applicants should have a Ph.D. and experience in related areas of theoretical and/or observational astronomy. To apply, please submit a curriculum vitae, statement of research interests, and contact information for three references to Dr. Sally Oey at the above address. Applicants must also submit a Lowell Observatory application form available at `http://www.lowell.edu/hr/jobs.html`, or upon request at the above address from Human Resources, Lowell Observatory, phone +1-928-774-3358, fax +1-928-774-6296. Applications received by 30 November 2003 will receive first priority. The full job description is available at the website above; inquiries are welcome to Sally.Oey@Lowell.edu or +1-928-774-3358.

Lowell Observatory is an equal opportunity employer and prohibits discrimination in all its programs and activities on the basis of race, color, national origin, religion, age, disability, political beliefs, sexual orientation, and marital and family status. Lowell Observatory provides reasonable accommodations to applicants with disabilities. The campus is at an elevation of 7000ft/2300m.

Address: Sally Oey, 1400 W. Mars Hill Rd., Flagstaff, AZ 86001, USA
`http://www.lowell.edu/~oey`; `http://www.lowell.edu/hr/jobs.html`

Meetings

The Nature and Evolution of Disks around Hot Stars

Date and Location

A workshop on disks around hot stars is being planned for 2004 July 7-9, to be hosted by East Tennessee State University in Johnson City, Tennessee (www.etsu.edu), with meetings to be held at the Carnegie Hotel (www.CarnegieHotel.com).

Motivation and Goals

Disks are an important, sometimes even dominant, feature of many astrophysical sources, including massive hot stars. Studies of these disks are often constrained by narrow categories of objects, while the key physical principles for understanding the disks in different systems can be quite similar. This workshop is intended to focus discussion on the major outstanding questions surrounding the structure, formation, and evolution of disks around hot stars, and to foster communication between different areas of disk research. With a balanced menu of observational and theoretical presentations, review talks will highlight recent results and key physical principles relating to these topics. In keeping with the workshop theme, substantial time will be allocated for discussion, both in a moderated large group setting and in the casual formation of smaller circles of participants. The intended outcome of this event is the synthesis of the latest observational data and theoretical tools to stimulate fresh approaches for this interesting and growing topic of relevance for massive stars.

Speakers

- Jon Bjorkman, University of Toledo - *Modelling the Structure of Hot Star Disks*
- Karen Bjorkman, University of Toledo - *The Observed Properties of Hot Star Disks*
- Joseph Cassinelli, University of Wisconsin - *The Effects of Magnetic Fields in Winds and Disks*
- Janet Drew, Imperial College - *Winds from Hot Star Disks* - (tbc)
- Carol Grady, NASA Goddard - *Evidence of Disks in Herbig Stars*
- Lee Hartmann, Harvard-Smithsonian CfA - *The Physics of Circumstellar Disks* - (tbc)
- Huib Henrichs, University of Amsterdam - *Magnetism Observed in Massive Stars* - (tbc)
- Michael Jura, University of California-Los Angeles - *Dusty Disks Across the HR Diagram*
- Keith MacGregor, High Altitude Observatory, National Center for Atmospheric Research- *Generating Magnetic Fields in Early-Type Stars*
- Georges Meynet, Geneva Observatory - *The Influence of Rotation for Massive Star Evolution: Principles and Uncertainties*
- Stan Owocki, Bartol Institute, University of Delaware - *Dynamical Processes that Drive the Evolution of Hot Star Disks* - (tbc)
- Thomas Rivinius, Landessternwarte Konigstuhl - *Links Between Hot Stars and Their Disks*

("tbc" indicates that the speaker is tentatively confirmed)

Pre-registration

If you are interested in attending, please help us estimate the number of potential attendees by sending an e-mail to
`hotstars@mail.etsu.edu`
Please use the following format:
Name:
Institution:
Email:
Level of Interest: <insert a number from below>

1 = high = Definitely plan to attend,
2 = med = Likely to attend, but not definite yet, and
3 = low = Interested in further information, but not sure yet whether will attend

* Note that all contributions will be in poster format, to maximize discussion opportunities. Only the review talks will be scheduled for oral presentation; much of the workshop will be in the open discussion.

Format

We have developed a novel format for the meeting. For each day there will be four invited talks in the morning, with a discussion session in the early afternoon. A "Focus" session will be held later in the afternoon, for which attendence will be optional.

Our goal is twofold: first, to provide review talks to summarize the current understanding of hot star disks and set the stage for discussion (the three sessions being "The Properties of Hot Star Disks", "The Star-Disk Connection", and "Magnetic Fields in Massive Stars"). A lunch break will provide a period of time for informal discussion, after which participants will gather for a moderated discussion led by a panel. The Focus sessions are more narrowly defined and are intended to be somewhat tutorial in nature, on the topics of Diagnostic Methods (headed by David Cohen and Margaret Hanson), Modelling Tools (headed by Ken Gayley and John Porter), and Optical/IR Interferometry (headed by Doug Gies and Philippe Stee).

The workshop format is thus built around a relatively small number of review talks, with plenty of time for interaction, in hopes of achieving a kind of "summer school" flavor. We would like participants to come away with a deeper understanding of the key issues and with new ideas for attacking the outstanding questions surrounding hot star disks. We hope to stimulate new collaborations and working partnerships for further progress in this area.

Questions

For questions or more information, contact
`hotstars@mail.etsu.edu`

SOC

Richard Ignace (East Tennessee State U) ; Karen S. Bjorkman (U of Toledo) ; Joseph P. Cassinelli (U of Wisconsin) ; Kenneth G. Gayley (U of Iowa)

Eta Carinae and the Fate of the MOST Massive Stars
Preliminary Announcement

During the past several years it has become increasingly apparent that eta Carinae and the rare objects like it, are telling us something about how the MOST massive stars end their lives.

Eta Carinae, the most massive and most luminous star in our region of the Milky Way, has received considerable attention in past decade, but the cause of its basic instability and its great eruption are still a mystery. It is a very evolved, highly unstable star with an initial mass probably greater than 100 Msun and we think it is nearing the end of its life. Eta Car is also the site of a spectacular bipolar nebula, the highest continuous mass loss rate for massive stars, and a peculiar 5.5 year spectroscopic cycle.

The recent extensive surveys for supernovae have also produced a growing class of objects that may not be true supernovae at all, the eta Car analogs or supernovae impostors.

The purpose of this meeting is to explore the behavior and characteristics of eta Car and its related objects, the origin of their instabilities, and the final stages of the most massive stars and their relation to hypernovae and GRB's. We want to bring together people working on the most massive stars with those studying the final stages, SNe and GRB's.

Brief outline of the topics to be covered

I. Setting the Stage (Eta Car 1800 to 2004) - eta Carinae's photometric and spectroscopic history and behavior covering the entire electromagnetic spectrum from X rays to radio

II. Results of Recent Work on Eta Carinae the HST Treasury Project and other studies: the central star (mass loss and wind, its evolutionary state), inner ejecta and Weigelt blobs (physics of the excitation processes), the Homunculus and outer ejecta (physics of the ejection)

III. Eta Car Analogs (SNe impostors?), Type IIn SNe's SN61v, SN1994j (V12 in N2403), V1 in N2366, SN1997bs, P Cyg(?) etc.

IV. Physics of the Instability – the Eddington Limit and Beyond

V. The evolution of most massive stars at different metallicities Relation to the first stars in the Universe; clues to their structure, evolution, and final stages.

VI. Models for the final stages of the MOST massive stars Relation to SNe types and hypernovae

VII. Relation to GRBs. The collapsar model and rotation in the advanced stages.

Scientific Organizing Committee:
Dave Arnett (Univ. Arizona), Kris Davidson (Univ. Minnesota), Gary Ferland (Univ. Kentucky), Alex Filippenko (Univ. California), Alexander Heger (Los Alamos Natl. Lab.), John Hillier (Univ. Pittsburgh), Roberta Humphreys (Univ. Minnesota), Andre Maeder (Geneva Observatory, Switzerland), and Kris Stanek (Harvard Univ.).

Date and Venue:
The exact date and site for the meeting has not been decided, but we plan to have the meeting in the early summer 2004 either immediately before (May 23- 28) or after (Jun 6 - 11) the American Astronomical Society meeting in Denver. We are looking at potential sites in the Jackson Hole area of Wyoming and Santa Fe/Taos, New Mexico.

Purpose of this preliminary announcement:
To solicit your interest in this meeting. We would appreciate it if you would return the form below. Also please forward this message to any of your colleagues who might be interested.

```
            SEND TO:  massive@etacar.umn.edu

1. I am interested in this meeting, please keep me on the email list.
    name:
    preferred email address:

2. I am interested and will probably attend this meeting, please keep me
    on the email list.
    name:
    preferred email address:

    I am interested in presenting a paper/poster on:
    other comments:
```

http://aps.umn.edu/mailman/listinfo/massive-announce

Massive Star Birth
Update on a Proposed Meeting

The planned IAU Symposium on Massive Star Birth which was proposed to the IAU for September 2004 in Sicily was not approved at the recent IAU Executive Committee meeting. It has been suggested to the organizers by Dr. Karel van der Hucht, the new Asst. General Secretary of the Union, that an improved proposal for a similar type of meeting in 2005 might be more favorably received.

Drs. Churchwell & Conti, the SOC Chairs for this proposal, plan to revise the program with input from the SOC so that it might be reconsidered for fall 2005. The recent successful launch of SIRTF might well aid in this regard.