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Accepted Papers

New catalogue of Wolf-Rayet galaxies and high-excitation extra-galactic H II regions

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We present a new compilation of Wolf-Rayet (WR) galaxies and extra-galactic H II regions showing *broad* He II λ4686 emission drawn from the literature. Relevant information on the presence of other broad emission lines (N III λ4640, C IV λ5808 and others) from WR stars of WN and WC subtypes, and other existing broad nebular lines is provided.

In total we include 139 known WR galaxies. Among these, 57 objects show both broad He II λ4686 and C IV λ5808 features. In addition to the broad (stellar) He II λ4686 emission, a *nebular* He II component is well established (suspected) in 44 (54) objects. We find 19 extra-galatic H II regions without WR detections showing nebular He II λ4686 emission.

The present sample can be used for a variety of studies on massive stars, interactions of massive stars with the ISM, stellar populations, starburst galaxies etc. The data is accessible electronically and will be updated periodicaly.

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Paper and information on database access also on the web at

`http://www.obs-mip.fr/omp/astro/people/schaerer/`

A Multi-Wavelength Campaign on γ Cas. III. The Case for Magnetically-Controlled Circumstellar Kinematics

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In two previous papers we have discussed simultaneous *RXTE* and *HST/GHRS* observations made of γ Cas (B0.5e) over a full day on 14–15 March 1996. The light curves generated from these data show features which anticorrelate and led us to conclude that the star has multiple surface activity centers which rotate into view every rotational cycle of 1.123 days. In a second paper we found that dips in the UV continuum (UVC) light curve are probably caused by the passage of cool, co-orbiting clouds which are suspended above surface X-ray active centers. In this paper we use difference spectra from our 21^{+}-hour *GHRS* time series to investigate $\leq$2% spectral variations within the photospheric Si IV $\lambda\lambda$1394–1403 lines as well as smaller variations from features in neighboring wavelengths at $\lambda\lambda$1382—1386 and $\lambda\lambda$1404—1417. Several difficulties arise in interpreting these variations as signatures of surface inhomogeneities, so we have studied both types of variations in the context of the kinematics of occulting circumstellar (CS) structures.

By means of model-atmospheres codes and up-to-date line lists, we computed a grid of cloud opacity for various temperatures in our spectral range. Using these synthetic spectra, we are able to identify features as optically thick absorptions due to Fe II, Cr II, and C I lines from "cool" (T < 10,000K) plasma, of Si IV, Si III, S IV, & Ni II lines from "warm" plasma ($\sim$10,000—18,000K), and of Si IV and Fe V lines from hot plasma ($\geq$30,000K). The variations of the cool- and hot-plasma lines are in phase with the UVC light curve while the warm-plasma line curves lead these curves by 3–4 hours. The cool- and warm-plasma lines participate in the blue-to-red deceleration and appear to be analogs of "migrating subfeature" (MSF) pattern found in optical lines by previous observers. The velocity range for these lines is consistent with limits of $\pm$Vsin i, suggesting that they are formed in co-rotating cloudlets which are distinct from the cool clouds we studied in Paper II. In contrast, warm and hot-plasma lines are "ultrasharp features" (USFs) which maintain a constant velocity for several hours. The USFs are visible over a wide velocity range, in some cases having a velocity of at least +1500 km s^{-1}.

Both cooling and heating of circumstellar plasma is consistent with the existence of strong nonradiative processes operating in some regions above γ Cas. Additionally, the migrating subfeatures find a ready explanation in circumstellar cloudlets forced by magnetic forces into co-rotation, as was also inferred from the UVC light curve in Smith, Robinson, & Hatzes. The existence of the stationary ultrasharp absorption features, particularly at large positive velocities, is difficult to explain unless one invokes interactions between magnetic loops from the star and a putative field in the circumstellar disc. This

picture holds the potential of explaining the hot, flaring character of this star's X-rays and predicts the existence of other X-ray-emitting γ Cas-analogs as magnetic Be stars having dense CS discs.

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The interacting early-type binary BD $+40°4220$ (= V 729 Cyg) Modelling the colliding winds region

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We present the analysis of an extensive set of spectroscopic observations of the mysterious early-type binary BD $+40°4220$. A new orbital solution is derived from the radial velocities of the absorption lines. We confirm that the secondary star is highly overluminous for its mass. The absorption lines of both components display phase-locked profile variations with some of the secondary's lines going into emission between $\phi = 0.20$ and $\phi = 0.55$. A detailed investigation of the profile variability of the He II $\lambda\,4686$ emission line reveals that the pattern of variability of this line is very stable. It is shown that part of the He II $\lambda\,4686$ emission is produced in the wind interaction region between the stars. Most of the emission lines in the visual spectrum of BD $+40°4220$ display variations that are reminiscent of those observed on the He II $\lambda\,4686$ line, pointing towards a similar origin.
We present numerical simulations of emission line profiles in a colliding winds binary, showing that an important part of the variability observed in BD $+40°4220$ can be explained by a colliding winds phenomenon. The properties of the wind interaction region can be accounted for if we assume that the secondary star is an evolved object, most probably some kind of Ofpe/WN9 transition star with a mass loss rate of $\sim 5.5\,10^{-5}\,\mathrm{M_\odot\,yr^{-1}}$. We finally discuss the fundamental parameters of the binary, concluding that mass transfer must have played a crucial role in the evolution of this system.

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Photometric behaviour of η Carinae, a celestial Chinese lantern: 1974–1998

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We discuss 24 y of optical photometry made between 1994 and 1998. Various conclusions from our previous photometric studies are confirmed. The core hides a normal S Dor variable (or LBV): it shows light variations on a time scale of 1–4 y, with superimposed micro oscillations whose quasi-period indicates a temperature in the order of 22 000 K. Therefore, a more complicated model for

η Car is necessary to explain its extraordinary appearance and phenomena exhibited in the past and at present.

An analysis of the brightness of η Car in the ultraviolet (UV) passbands of three photometric systems (Walraven, Strömgren and Geneva) reveals the presence of an important variable UV source, which appears to be modulated with the 5.52 y period of the spectroscopic events, related to the possible revolution of an excentric binary of the type proposed by Damineli et al. (1997).

Our new data support the luminous disk model suggested by van Genderen et al. (1994, 1995). A very hot companion of the LBV would be responsible for the excitation of the disk.

We suspect that the flare-like event in the X-ray flux and in the optical and near-infrared light around 1998.0 was the result of the encounter of the interface of the colliding winds of the binary with an arm-shaped density enhancement in a disk around the LBV (not necessarily "the" luminous disk). We suppose that this encounter created an intense X-ray/hot spot region. The subsequent steep decline of the flare is ascribed to an eclipse of the X-ray/hot spot by the interface.

The radio flux variation of the gas torus in the equatorial plane at a distance of $2''$ from the core, could be the result of the luminous disk becoming optically thin. This would, obviously, start abruptly near the time of periastron passage and would last for a few years thereafter, so that a hot star, normally enshrouded by the disk, is able to excite the outer gas torus. The creation of the X-ray/hot spot, with a life-time of at most a few months, could also be the cause of the instantaneous physical change of the luminous disk mentioned above (and its 5.52 y modulation) visible in the UV, since both happen at the same time.

Apart from the 5.52 y period in the UV, we found a striking 200 d-oscillation, also in the UV, during the last orbital cycle between 1992.5 and 1998.0. Its possible explanation depends on whether it is cyclic or truly periodic (in the latter case η Car could hide a triple star).

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Eighteen Years of IUE Observations of Eta Carinae

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The ultraviolet spectrum of the superluminous southern variable η Car was estensively studied with the *International Ultraviolet Explorer* (IUE) from February 1978 to July 1996, which not only allowed the first detailed studies of its UV spectrum, but also provided a unique opportunity to study the UV spectral variability of a massive star over a very long period of time. We describe the main results on the spectroscopic features of the stellar wind, such as the large ionization range, the high terminal velocity, and the carbon underabundance, and compare them with HST spectroscopic observations. We also illustrate the long term variations associated to the recently discovered 5.52 y cycle, and discuss them in the framework of the binary hypothesis.

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The Gamma Vel binary system: I. O Star Paramters and Light Ratio

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In this paper we demonstrate how previous determinations of the light ratio between the O and Wolf-Rayet stellar components of the γ Vel system are affected by large uncertainties. This is due, amongst other things, to the difficulty of measuring the equivalent widths of emission and absorption lines. We then present a new technique to de-blend and measure spectral lines, in which we compensate for the observed absorption features with synthetic profiles. From the new values of the diagnostic line strengths we determine a hotter spectral type for the O star companion (O7.5) than previously published.

The light ratio is then determined, together with the stellar parameters, via a spectroscopic analysis. We obtain ΔM_V=1.47±0.13 mag. From the light ratio and the system's luminosity we find M_V(O) = –5.14 mag and M_V(WR) = –3.67 mag. Simultaneously we determine $T_{\rm eff}$(O) = 35 000 K, L(O) = 2.1×10^5 $L_\odot$ and $\mathcal{M}$(O) = 30 $M_\odot$. An age of 3.59×10^6 yr is derived from these parameters and evolutionary tracks. We find that the H/He abundance ratio is solar. From a hydro-dynamical calculation of the radiation-driven wind we obtain $\dot{M}$(O) = 1.8×10^{-7} $M_\odot$ yr^{-1} and v_∞(O) = 2500 km s^{-1}.

From the O star mass derived here and the mass ratio from the literature we derive the mass of the Wolf-Rayet star, $\mathcal{M}$(WR) = 9 $M_\odot$. The mass-luminosity relation for Wolf-Rayet stars then leads to L(WR) = 1.5×10^5 $L_\odot$. We finally present the γ Vel Wolf-Rayet spectrum de-convolved from the O star in the range 3800-6700 Å.

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Implications of 1.8 MeV gamma-ray Observations

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Recent analysis of COMPTEL data revealed an extremely close correlation between 53 GHz microwave free-free and 1.8 MeV gamma-ray line emission (Knödlseder et al. 1998). While microwave free-free emission arises from the ionized interstellar medium, 1.8 MeV gamma-rays are emitted during the radioactive decay of ^{26}Al. We argue that the close correlation can only be understood if massive stars ($M \gtrsim 20M_\odot$) are at the origin of galactic ^{26}Al. Based on the measured proportionality factor we estimate the ^{26}Al yield of an "equivalent O7 V star" to be $(1.0 \pm 0.5) \times 10^{-4} M_\odot$. Using an estimate for the total galactic Lyman continuum luminosity of $Q = 3.5 \times 10^{53}$ ph s^{-1} we derive the galactic ^{26}Al mass to be $3.1 \pm 0.9 M_\odot$. The mass estimate is compared to theoretical nucleosynthesis predictions for ^{26}Al from core collapse supernovae and Wolf-Rayet stars. We circumvent the problem of using a weakly constrained star formation rate for this comparison by determining the star formation rate self-consistently from our models using the galactic Lyc luminosity. The effects of mass loss and metallicity are considered and the uncertainties of predicted ^{26}Al production rates due to poorly known initial mass limits for the candidate sources are discussed. Assuming solar metallicity throughout the entire Galaxy,

we predict a galactic ^{26}Al mass of $1.6 \pm 0.3 M_{\odot}$ of which $\sim 60\%$ is produced by core collapse supernovae while $\sim 40\%$ originates from Wolf-Rayet stars. Taking into account the galactic metallicity gradient increases the galactic ^{26}Al mass to $2.2 \pm 0.4 M_{\odot}$ which is consistent with the observed value. The increase mainly comes from enhanced production by Wolf-Rayet stars in the metal-rich inner Galaxy which contribute $\sim 60\%$ to the galactic ^{26}Al budget. We predict that the metallicity gradient should produce an inner-to-outer Galaxy intensity contrast of $\sim 30\%$ between 1.8 MeV and galactic free-free emission, which should be observable by the future gamma-ray spectrometer SPI on INTEGRAL.

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A Multiwavelength Comparison of COMPTEL 1.8 MeV ^{26}Al Line Data

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We search for correlations between 1.809 MeV γ-ray line emission, attributed to the radioactive decay of ^{26}Al, and intensity distributions observed at other wavelengths by confronting *CGRO* COMPTEL 1.8 MeV data with an extended database of all-sky maps. The database contains 31 all-sky maps, covering the entire explored wavelength range from the radio band up to high-energy gamma-rays. Different data analysis techniques are explored to determine the similarities between the all-sky maps and the 1.809 MeV intensity distribution, and to estimate the systematic uncertainties of our study. The comparison shows that tracers of the old stellar population or the local interstellar medium provide only a poor description of COMPTEL 1.8 MeV data. Tracers of the young stellar population considerably improve the fit, confirming our earlier claims that ^{26}Al nucleosynthesis is associated to massive stars. Residuals are minimal for the 53 GHz free-free emission map that has been obtained by *COBE* DMR at microwave wavelengths. Within the statistics of the present data, this tracer provides an entirely satisfactory fit to COMPTEL 1.8 MeV data. Thus, a correlation has been discovered, linking galactic ^{26}Al nucleosynthesis to galactic free-free emission which is a tracer of the ionised interstellar medium.

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Very young massive stars in the Small Magellanic Cloud, revealed by *HST*

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High spatial resolution imaging with the *Hubble Space Telescope* allowed us to resolve the compact H II region N81 lying in the Small Magellanic Cloud (SMC). We show the presence of a tight cluster of newborn massive stars embedded in this nebular "blob" of $\sim 10''$ across. This is the first time the stellar content and internal morphology of such an object is uncovered. These are among the youngest massive stars in this galaxy accessible to direct observations at ultraviolet and optical wavelengths. Six of them are grouped in the core region of $\sim 2''$ diameter, with a pair of the main exciting stars in the very center separated by only $0''.27$ or 0.08 pc. The images display violent phenomena such as stellar winds, shocks, ionization fronts, typical of turbulent starburst regions. Since the SMC is the most metal-poor galaxy observable with very high angular resolution, these observations provide important templates for studying star formation in the very distant metal-poor galaxies which populate the early Universe.

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`or http://xxx.lanl.gov/abs/astro-ph/9901270`

The orientation within the Galaxy and the Large Magellanic Cloud of nebulae ejected by massive stars

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The orientation of nebulae ejected by massive stars (Luminous Blue Variables, WR stars, SN1987A) is investigated with respect to the structure of the galaxy to which they belong.

In the Galaxy, we find that the projected long axes of the nebulae most often align with the galactic plane, and then also with the galactic magnetic field. This alignment is statistically significant. In addition, a few nebulae are apparently oriented perpendicular to the galactic plane. In the Large Magellanic Cloud, the nebular axes are found to closely follow the spiral magnetic field. With different inclinations, the Galaxy and the Large Magellanic Cloud probably offer complementary views of the same phenomenon.

Although the sample studied thus far is small and the statistics limited, these results suggest that the orientation of massive star ejecta depends on galactic magnetic fields.

Since the nebular axes are apparently correlated to the symmetry axes of the stars themselves, and since, in the early evolutionary stages, alignments of accretion disk axes with the interstellar magnetic field have been reported, it is argued that the observed alignment effect results from the star formation process.

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Hα spectropolarimetry of B[e] and Herbig Be stars

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We present the results of medium resolution ($\Delta v \approx 60$ km s^{-1}) spectropolarimetric observations across Hα of a sample of B[e] and Herbig Be objects. A change in linear polarization across Hα is detected in a large fraction of the objects, with characteristics ranging from simple depolarization in a couple of Herbig Be stars, to more complex behaviour in the probable post main sequence B[e] stars. Hα in the spectra of HD 37806 and HD 50138 each consist of a double-peaked polarized line and a superposed unpolarized single emission peak, suggesting two distinct line-forming regions. Multiple observations of HD 45677 allow for the separation of electron and dust scattering effects for the first time: the difference between derived intrinsic polarization angles of the two components indicate that the dust-scattering region is clumpy. Two unexpected results are the non-detections of Hα polarization changes in ω Ori, where depolarization has previously been detected, and in MWC 297, which exhibits source elongation at radio wavelengths. In ω Ori time variability is probably responsible such that this star's electron-scattering disk was much weakened at the time of observation. Two hypotheses are advanced that might explain the MWC 297 result.

The general findings are that roughly half of the observed Herbig Be stars show polarization changes across Hα, implying immediately that their ionized envelopes are not spherically symmetric. This pattern, if confirmed by observations of a larger sample, could indicate that the non-detection rate is simply a consequence of sampling randomly-oriented circumstellar disks able to scatter starlight within a few stellar radii. The stars classified as B[e] stars all show startling polarization changes across Hα. The details in each case are different, but the widely accepted concept of dense Hα-emitting equatorial disks around these objects is supported.

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Non-radial pulsations in the O stars ξ Per and λ Cep

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A new time-series analysis of profile changes in the photospheric He I λ4713 spectral line from data taken during 5 days in 1989 at the Calar Alto and Kitt Peak observatories has provided evidence for the presence of a non-radial prograde p-mode in the O 7.5 giant ξ Per ($\ell = 3$, $P = 3.5$) and probably two such modes in the O6 supergiant λ Cep ($\ell = 3$, $P = 12.3$ h and $\ell = 5$, $P = 6.6$ h). The corotating pulsation periods are in both cases much shorter than the estimated stellar rotation period. Modeling the observed amplitude of the line-profile changes (assuming $|m| = \ell$) yields a velocity amplitude of approximately 5 km s^{-1} of the pulsation in ξ Per and 6 km s^{-1} in λ Cep.

Any such a pulsation by itself is unlikely to be the cause of the well-known cyclical wind variability in these stars because the pulsation period is too short, but the cumulative action of multiple modes could

cause such an effect. Weak magnetic fields anchored at the surface remain the strongest candidate for the origin of wind variability.

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Long- and short-term variability in O-star winds II. Quantitative analysis of DAC behaviour

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A quantitative analysis of time series of ultraviolet spectra from a sample of 10 bright O-type stars (cf. Kaper et al. 1996, Paper I) is presented. Migrating discrete absorption components (DACs), responsible for the observed variability in the UV resonance doublets, are modeled. To isolate the DACs from the underlying P Cygni lines, a method is developed to construct a template ("least-absorption") spectrum for each star. The central velocity, central optical depth, width, and column density of each pair of DACs is measured and studied as a function of time.

It turns out that the column density of a DAC first increases and subsequently decreases with time when the component is approaching its asymptotic velocity. Sometimes a DAC vanishes before this velocity is reached. In some cases the asymptotic DAC velocity systematically differs from event to event.

In order to determine the characteristic timescale(s) of DAC variability, Fourier (CLEAN) analyses have been performed on the time series. The recurrence timescale of DACs is derived for most targets, and consistent results are obtained for different spectral lines. The DAC recurrence timescale is interpreted as an integer fraction of the stellar rotation period. In some datasets the variability in the blue edge of the P Cygni lines exhibits a longer period than the DAC variability. This might be related to the systematic difference in asymptotic velocity of successive DACs.

The phase information provided by the Fourier analysis confirms the expected change in phase with increasing velocity. This supports the interpretation that the DACs are responsible for the detected periodicity. The phase diagram for the O giant ξ Per shows clear evidence for so-called "phase bowing", which is an observational indication for the presence of curved wind structures like corotating interaction regions in the stellar wind. An important difference with the results obtained for the B supergiant HD 64760 (Fullerton et al. 1997) is that in this O star the phase bowing can be associated with the DACs. No other O stars in our sample convincingly show phase bowing, but this could be simply due to the absence of periodic signal and hence coherent phase behaviour at low wind velocities.

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Towards understanding rapid line-profile and light variations of early-type stars
3. Some thoughts and reflections

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The current situation in the research of rapid line-profile and light variations of early-type stars is critically reviewed. It is suggested that the ultimate understanding of the physical processes causing these variations can only come from an open-minded and complex approach to the problem and from systematic observational effort. It is argued that the results of the search for periodicities in the complicated variations of these objects depend critically on whether the method used is appropriate to the real physical situation. The danger of detection of a false multiperiodicity is pointed out for two particular situations: (i) a single-periodic signal which undergoes slow periodic change, e.g., due to the light time effect in a binary system, and (ii) a single-periodic signal with a complicated phase curve (a model of not exactly equidistant corotating spokes). It is argued that the observed rapid variations need not be due to classical non-radial pulsations but may arise from more complicated velocity fields in the stellar atmospheres and/or mantles.

Two early-type stars, ε Per and ζ Oph, are discussed in detail. It is argued that both may be the cases where the variations are caused by corotating structures slightly above the stellar photosphere. For ε Per, the pattern of the variations can also be affected by the motion of the star in a binary orbit. For ζ Oph, a double-wave light curve with the corotation period of $0\overset{\mathrm{d}}{.}64$ (suggested by the author earlier for the line-profile variations) was found from Hipparcos V photometry and its presence can also be suspected in other existing photometric data and in the recurrence times of the narrow features seen in the UV spectra.

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Submitted Papers

A Simple Scaling Analysis of X-ray Emission and Absorption in Hot-Star Winds

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We present a simple analysis of X-ray emission and absorption for hot-star winds, designed to explore the natural scalings of the observed X-ray luminosity with wind and stellar properties. We show that an exospheric approximation, in which all of the emission above the optical depth unity radius escapes the wind, reproduces very well the detailed expression for radiation transport through a spherically symmetric wind. Using this approximation we find that the X-ray luminosity L_x scales naturally with the wind density parameter $\dot{M}/v_\infty$, obtaining $L_x \sim (\dot{M}/v_\infty)^2$ for optically thin winds, and

$L_x \sim (\dot{M}/v_\infty)^{1+s}$ for optically thick winds with an X-ray filling factor that varies in radius as $f \sim r^s$. These scalings with wind density contrast with the commonly inferred empirical scalings of X-ray luminosity with the bolometric luminosity L_{bol}. The empirically derived linear scaling of $L_x \sim L_{bol}$ for thick winds can however be reproduced, through a delicate cancellation of emission and absorption, if one assumes a modest radial fall-off in the X-ray filling factor ($s \approx -0.25$ or $s \approx -0.4$, depending on details of the secondary scaling of wind density with luminosity). We also explore the nature of the X-ray spectral energy distribution in the context of this model, and find that the spectrum is divided into a soft, optically thick part and a hard, optically thin part. Finally, we conclude that the energy-dependent emissivity must have a high-energy cut-off, corresponding to the maximum shock energy, in order to reproduce the general trends seen in X-ray spectral energy distributions of hot stars.

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A near IR adaptive optics search for faint companions to early-type multiple stars

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We report on a high dynamical range ($> 10^m$) and high angular resolution (down to $0.2''$) search for low-mass components to early-type primaries in 7 intermediate-age (5 Myr) multiple systems, using the ESO 3.6 m telescope with the adaptive optics system ADONIS. The images were obtained in J and SK bands with and without a coronographic mask of $2''$ diameter. The census is nearly complete in the angular separation range $1'' - 6''$, corresponding to the linear separations of $200 - 1200$ AU, which remained unstudied so far due to the intrinsic brightness of the massive primaries. The best detection limits are around $K = 15^m$ at $1''$ and $K = 19^m$ at $5''$ from the primary. In 13 fields of $12.5'' \times 12.5''$, 6 new faint stars were detected. Their magnitudes and colours indicate that 2 of them can well be physical low-mass components. The bright ($K = 11.2$, $J - K = 1.2$) companion to HD 108250 C at $2.17''$ has an IR excess and deserves further study. Some fields were explored without mask; somewhat surprisingly, no new components at sub-arcsecond separations down to $0.2''$ were detected. The first order stability analysis indicates that the studied multiple systems are hierarchical at the spatial scales $40 - 1000$ AU. The data are briefly discussed in the light of the formation and evolution of the multiple systems with massive primaries.

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In Proceedings

The Influence of Massive Stars on the Interstellar Medium

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On scales ranging from pcs to kpcs, the relationship between stellar and gaseous galactic components forms the basis for interpreting observations of galaxies and understanding galaxy formation and evolution. Feedback effects from massive stars dominate the structure, ionization, kinematics, and enrichment of the gaseous ISM in star-forming galaxies. On galactic scales, the ionizing radiation from these stars creates populations of HII regions and the diffuse, warm ionized medium. Likewise, superbubbles created by stellar winds and supernovae strongly influence the structure, kinematics, and balance of the multiphase ISM. This contribution reviews these feedback effects of massive stars on the global ISM.

Review paper to appear in *Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies*, **IAU Symp. 193, eds. K. A. van der Hucht, G. Koenigsberger, & P. R. J. Eenens.**
Preprints from `oey@stsci.edu`
or on the web at `http://icarus.stsci.edu/~oey/oeypubs.html`

Dynamics and Variability of Winds from Single WR Stars

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We review the dynamics of winds from single Wolf-Rayet (WR) stars, with emphasis on the following specific points: 1). The classical "momentum problem" (to explain the large inferred ratio of wind to radiative momentum, $\eta \equiv \dot{M} v_\infty/(L/c) \gg 1$) is in principle readily solved through multiple scattering of radiation by an opacity that is sufficiently "gray" in its spectral distribution. In this case, one simply obtains $\eta \approx \tau$, where τ is the wind optical depth. 2.) Lines with a Poisson spectral distribution yield an "effectively gray" cumulative opacity, with multi-line scattering occuring when the velocity separation between thick lines Δv is less than the wind terminal speed v_∞. In this case, one obtains $\eta \approx v_\infty/\Delta v$. 3.) However, realistic line lists are not gray, and leakage through gaps in the line spectral distribution tends to limit the effective scattering to $\eta < 1$. 4.) In WR winds, ionization stratification helps spread line-bunches and so fill in gaps, allowing for more effective global trapping of radiation, and thus $\eta > 1$. 5.) However, photon thermalization can reduce the local effectiveness of line-driving near the stellar core, making it difficult for radiation alone to initiate the wind. 6.) The relative complexity of WR wind initiation may be associated with the extensive turbulent structure inferred from observed variabililty in WR wind emission lines. 7.) Overall, the understanding of WR winds is perhaps best viewed as an "opacity problem", i.e. identifying the enhanced opacity that can adequately block the radiation flux throughout the wind, and thus drive a WR mass loss that is much greater than from OB stars of comparable luminosity.

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`www.bartol.udel.edu/~owocki/preprints/iaus193_owocki.ps.gz`

Dynamics and Variability of Winds in WR+O Binaries

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The presence of a nearby O star offers the potential for studying the response of a WR wind to external irradiation from a well-understood UV source. The O starlight offers not only a passive diagnostic probe, but also the potential for a dynamical interaction whose nature relates directly to fundamental issues of how WR winds are driven. It may even decelerate the WR wind prior to the wind/wind interaction, an effect we term *radiative braking*. We report on recent progress in WR+O wind-wind interaction models that incorporate the influence of the O starlight on the incident WR wind, and also the effect of the WR starlight on the acceleration of the O-star wind. A recurrent theme is the importance of feedback between the line force and the gas dynamics, and the leveraging that results.

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`www.bartol.udel.edu/ owocki/preprints/iaus193_gayley.ps.gz`

GraF/ADONIS spectro-imaging of η Carinae $0.9'' \times 12''$ central region.

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[2] European Southern Observatory, Casilla 16317, Santiago 19, Chile We present long slit spectroscopic and

3D-spectroscopic data of η Car at λ=1.67μm taken with the GraF instrument used with the ESO 3.6 m /ADONIS/SHARPII+. The successfully deconvolved data show the angular resolution of $0.1''$ and spectral resolution of 10 000, illustrating the power of this new instrument. The spots B and D (cf. Weigelt & Ebersberg 1986) are well detected at $0.14''$ and $0.21''$ to the NW from the central star, as well as the SE feature at about $0.7''$ described previously by Rigaut & Gehring (1995). Their spectrum in the lines of hydrogen Br11, [FeII] 1.6769 μm, and FeII 1.6783 μm, 1.6873 μm show different broadening and relative line strength. The central star emission is characterized by a large broadening ($\simeq$800 km/s), with Br11 stronger than FeII lines. The NW spots emit essentially in narrow ($\leq$150 km/s) FeII lines, while the SE feature spectrum is close in appearance to that of the central star. This suggests more reflexion and/or scattering for the SE feature, having therefore a higher dust/gas ratio than the NW spots.

To appear in conference proceedings of:
ESO/OSA Topical Meeting on Astronomy with Adaptive Optics.
Present Results and Future Programs, Sonthofen Sept.7-11, 1998
Preprints from the web at

http://www.eso.org/gen-fac/meetings/eso-osa98/proceedings/chalabaev2.ps.gz

Colliding winds in WR binaries: further developments within a complicated story

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We present large scale 3D simulations of colliding winds in the WR binary γ Velorum (WR 11). The O-star wind is confined by cold, high density shells and forms a spirally shaped region within the WR-wind. As a consequence of the elliptic orbit, the opening angle and the curvature of the spiral as well as the ratio of the volumes occupied by the WR- and the O-wind are functions of the orbital phase. Our model qualitatively reproduces the observed X-ray light curve. The impact of magnetic fields and heat conduction on the physics of colliding winds is briefly discussed and some remarks on the important question of stability are made.

IAU 193, Conference Proceedings

Preprints from walder@astro.phys.ethz.ch
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or on the web at http://www.astro.phys.ethz.ch/papers/walder/walder_p.html

Theses

Variable Central Stars of Young Planetary Nebulae

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A new class of variable star is proposed. These are variable central stars of young Planetary Nebulae exhibiting roughly sinusoidal (semi)regular photometric and/or radial velocity variations with time scales of several hours. Ten of these objects have been identified and they share two more important characteristics: their temperatures are less than 50 000 K and all show hydrogen-rich spectra. The most likely reason for the variability is stellar pulsation. Another possibility would be variable stellar mass loss, but in that case the mechanism causing it must be different from that operating in massive O stars.

Thesis defended at the University of Vienna in February 1999 (advisor Prof. Michel Breger).
Preprints from gerald@dsn.astro.univie.ac.at

Jobs

ARMAGH OBSERVATORY
POSTDOCTORAL RESEARCH ASSISTANT

Pulsations in Early-Type Stellar Remnants

A PPARC-funded research position is available for up to three years, starting 1 May 1999 or as soon as possible thereafter. The position will involve making observational studies of pulsating stars, primarily early-type stellar remnants including extreme helium stars and hot subdwarfs. Work will be carried out in collaboration with Dr. Simon Jeffery. The preferred background is in observational or theoretical stellar astrophysics. Proven expertise in studies of stellar atmospheres and/or pulsations would be an advantage, although candidates with other relevant experience will be considered.

Research interests of Observatory staff include Stellar Astrophysics, Solar System Astronomy, and Solar System – Terrestrial Relationships. The Observatory receives regular awards of telescope time and research grants from the PPARC and other organizations. Computing facilities are excellent and include a local Starlink node. Further information about the Armagh Observatory may be obtained by consulting the Observatory web-site at http://www.arm.ac.uk.

Starting salary, depending on age and experience, will be on the University RA1A Scale in the range 15735 pounds to 17570 pounds (under review). Informal enquiries may be addressed to Dr. Simon Jeffery at the address below, or by e-mail to csj@star.arm.ac.uk.

The closing date for applications is 31 March 1999. Prospective applicants should obtain an application pack from the Administrator and send this, together with a full curriculum vitae and bibliography, to: The Administrator, Armagh Observatory, College Hill, Armagh BT61 9DG, Northern Ireland, U.K. (Tel: +44-(0)1861-522928, FAX: +44-(0)1861-527174, e-mail: lfy@star.arm.arc.uk). References from three referees should also reach the Administrator by the same date.

Armagh Observatory is an equal opportunities employer and welcomes applications from candidates irrespective of ethnic origin, religion, gender, political opinion, marital status, sexual orientation, or disability.

Meetings

TARTU WORKSHOP:

Thermal and Ionization Aspects of Flows From Hot Stars: Observations and Theory

Tartu (Estonia): August 23 - 27, 1999

FIRST ANNOUNCEMENT

Scope of the workshop:
Thermal and ionization aspects of flows from hot stars have been rarely discussed at the conferences and symposia about stellar winds. Yet it is crucial for understanding the mechanisms and processes in the winds of hot stars. Moreover the thermal and ionization structure of winds provides the diagnostic methods for the study of the winds by means of optical and UV spectroscopy, X-rays, IR- and radio fluxes.

During the last years an increasing numbers of X-ray observations and high resolution and high S/N optical spectra and UV spectra by HST have been obtained. In the near future the FUSE observations of spectra between 900 and 1200 Å will provide a wealth of new information about the ionziation of winds from hot stars. At the same time there has been a significant progress in numerical modelling of shocked winds and in the theory of colliding winds. Therefore it is time to have a workshop to discuss the present status, the expected progress, and the problems of the observations and theory of thermal and ionization structure of flows from hot stars.

Scientific program and contributions:
The scientific program is divided into three sessions.

A: SINGLE STARS
- A1 - Observations of the structure of winds of OB stars: *invited*
- A2 - Observations of the structure of winds of WR stars: *Tony Moffat*
- A3 - Observations of the structure of LBV-winds: *Indrek Kolka*
- A4 - Observations of the structure of B-star winds with small mass loss: *Joe Cassinelli*
- A5 - Theory of the ionization of hot star winds: *invited*
- A6 - Theory of instabilities and shocks in hot star winds: *Achim Feldmeier*

B: BINARIES
- B1 - Observations of the winds of symbiotic stars: *Hans Martin Schmid*
- B2 - Observations of the structure of winds in WR/OB binaries: *Anatoli Cherepashchuk*
- B3 - Theory of colliding winds of symbiotic stars: *Rolf Walder*
- B4 - Theory of thermal/ionization effects in colliding winds of WR/OB binaries: *invited*

C: SPECTRAL MODELLING AND DIAGNOSTICS
- C1 - Modelling and diagnostics of smooth winds: *Arved Sapar*
- C2 - Modelling and diagnostics of structured winds: *John Hillier*
- C3 - Spectral modelling and diagnostics of phase dependent observations of colliding winds: *invited*
- C4 - Spectral modelling and diagnostics of symbiotic stars: *Harry Nussbaumer*
- C5 - Dependence of matter outflows on stellar properties: *Henny Lamers*

The SOC has invited review speakers. There will be ample time for oral contributions, short contributions, poster sessions and discussion. The scientific sessions will be held on August 23, 24, 26, 27. Wednesday (Aug. 25) is reserved for an excursion.

We can accept about 70 participants. The participants are expected to present an oral contribution or a poster. The selection will be made by the SOC. The SOC accepts proposals for oral presentations (20 minutes) and for short oral contributions (10 minutes) or posters.

The proceedings will be published in the ASP-Conference Series (editors H.J.G.L.M. Lamers and A. Sapar).

Further information:
Information and registration form are available on the WWW page
`http://www.aai.ee/workshop/Tartu_workshop.html`
E-mail: `wshop@aai.ee`

Deadlines:
June 1, 1999: Registration Forms and Abstracts of scientific contributions.
July 15, 1999: Payment of Registration Fee.

FIRST ANNOUNCEMENT

ESO Workshop on

Black Holes in Binaries and Galactic Nuclei

their Diagnostics, Demography, and Formation

in honour of Prof. Riccardo Giacconi

6-8 September 1999

ESO Headquarters
Garching bei München, Germany

The aim of this workshop is to bring together astrophysicists working on the rather separate fields of stellar-mass and supermassive black holes, with emphasis on the formation, population, physics, and environments of black holes. An overview will be given of the observational evidence for the existence of black holes in binaries and galactic nuclei. Related topics like the late stages of (binary) evolution and galaxy formation will be addressed.

Topics to be covered include:

- **Black-hole diagnostics**
  Binaries (X-ray sources, neutron stars vs. black holes)
  Centers of galaxies, including our own (AGN phenomenon, stellar & gas dynamics signatures)
  Jets, disks & accretion tori
  Variability & outbursts
- **Properties of black-hole populations**
  Stellar-mass black holes
  Supermassive black holes
- **Black-hole formation**
  Progenitors of stellar-mass black holes: Supernovae/Hypernovae
  Models for the formation of supermassive black holes

Scientific Organizing Committee:
R. Bacon (France), R. Bender (Germany), R.D. Blandford (USA), P.T. de Zeeuw (Netherlands),

L. Kaper (Netherlands), G. Monnet (ESO), M.J. Rees (United Kingdom), A. Renzini (ESO), D.O. Richstone (USA), R. Sunyaev (Germany), Y. Tanaka (Japan), J. Trümper (Germany), E.P.J. van den Heuvel (Netherlands, Chair)

Local Organizing Committee:
L. Kaper (Netherlands, Chair), C. Stoffer (ESO), P. Woudt (ESO)

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