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Abstracts of 20 accepted papers

New Constraints on the Origin of the Short-Term Cyclical Variability of the Wolf-Rayet Star WR 46

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The Wolf-Rayet star WR 46 is known to exhibit a very complex variability pattern on relatively short time scales of a few hours. Periodic but intermittent radial velocity shifts of optical lines as well as multiple photometric periods have been found in the past. Non-radial pulsations, rapid rotational modulation or the presence of a putative low-mass companion have been proposed to explain the short-term behaviour. In an effort to unveil its true nature, we observed WR 46 with FUSE (Far Ultraviolet Spectroscopic Explorer) over several short-term variability cycles. We found significant variations on a time scale of ~8 hours in the far-ultraviolet (FUV) continuum, in the blue edge of the absorption trough of the O VI λλ1032,1038 doublet P Cygni profile and in the S VI λλ933,944 P Cygni absorption profile. We complemented these observations with X-ray and UV light-curves and an X-ray spectrum from archival XMM-Newton (X-ray Multi-Mirror Mission - Newton Space Telescope) data. The X-ray and UV light-curves show variations on a time scale similar to the variability found in the FUV. We discuss our results in the context of the different scenarios suggested to explain the short-term variability of this object and reiterate that non-radial pulsations is the most likely to occur.

Reference: ApJ, in press
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Investigating the X-ray emission from the massive WR+O binary WR 22 using 3D hydrodynamical models

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Aims. We examine the dependence of the wind-wind collision and subsequent X-ray emission from the massive WR+O star binary WR 22 on the acceleration of the stellar winds, radiative cooling, and orbital motion.

Methods. Three dimensional (3D) adaptive-mesh refinement (AMR) simulations are presented that include radiative driving, gravity, optically-thin radiative cooling, and orbital motion. Simulations were performed with instantaneously accelerated and radiatively driven stellar winds. Radiative transfer calculations were performed on the simulation output to generate synthetic X-ray data, which are used to conduct a detailed comparison against observations.

Results. When instantaneously accelerated stellar winds are adopted in the simulation, a stable wind-wind collision region (WCR) is established at all orbital phases. In contrast, when the stellar winds are radiatively driven, and thus the acceleration regions of the winds are accounted for, the WCR is far more unstable. As the stars approach periastron, the ram pressure of the WR's wind overwhelms the O star's and, following a significant disruption of the shocks by non-linear thin-shell instabilities (NTSIs), the WCR collapses onto the O star. X-ray calculations reveal that when a stable WCR exists the models over-predict the observed X-ray flux by more than two orders of magnitude. The collapse of the WCR onto the O star substantially reduces the discrepancy in the $2 - 10$ keV flux to a factor of $\simeq 6$ at $\varphi = 0.994$. However, the observed spectrum is not well matched by the models.

Conclusions. We conclude that the agreement between the models and observations could be improved by increasing the ratio of the mass-loss rates in favour of the WR star to the extent that a normal wind ram pressure balance does not occur at any orbital phase,
potentially leading to a sustained collapse of the WCR onto the O star. Radiative braking may then play a significant role for the WCR dynamics and resulting X-ray emission.

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WR 110: A Single Wolf-Rayet Star With Corotating Interaction Regions In Its Wind?

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A 30-day contiguous photometric run with the MOST satellite on the WN5-6b star WR 110 (HD 165688) reveals a fundamental periodicity of P = 4.08 +/- 0.55 days along with a number of harmonics at periods P/n, with n ~ 2,3,4,5 and 6, and a few other possible stray periodicities and/or stochastic variability on timescales longer than about a day. Spectroscopic RV studies fail to reveal any plausible companion with a period in this range. Therefore, we conjecture that the observed light-curve cusps of amplitude ~ 0.01 mag that recur at a 4.08 day timescale may arise in the inner parts, or at the base of, a corotating interaction region (CIR) seen in emission as it rotates around with the star at constant angular velocity. The hard X-ray component seen in WR 110 could then be a result of a high velocity component of the CIR shock interacting with the ambient wind at several stellar radii. Given that most hot, luminous stars showing CIRs have two CIR arms, it is possible that either the fundamental period is 8.2 days or, more likely in the case of WR 110, there is indeed a second weaker CIR arm for P = 4.08 days, that occurs ~ two thirds of a rotation period after the main CIR. If this interpretation is correct, WR 110 therefore joins the ranks with three other single WR stars, all WN, with confirmed CIR rotation periods (WR 1, WR 6, and WR 134), albeit with WR 110 having by far the lowest amplitude photometric modulation. This illustrates the power of being able to secure intense, continuous high-precision photometry from space-based platforms such as MOST. It also opens the door to revealing low-amplitude photometric variations in other WN stars, where previous attempts have failed. If all WN stars have CIRs at some level, this could be important for revealing sources of magnetism or pulsation in addition to rotation periods.

Reference: ApJ
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Wind structure of the Wolf-Rayet star EZ CMa=HD 50896

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The Wolf-Rayet star HD 50896 (EZ CMa=WR6) is well-known for the emission-line profile variability that occurs on a 3.7-day timescale. In particular, the shape of the N V 4604-21 doublet changes from a P Cygni profile to one in which no blue-shifted absorption component is present. In this paper we use spectroscopic observations obtained in 1991, 1999, 2005 and 2009 to glean physical conditions within the stellar wind that may give rise to these changes. We find that variations in the opacity at a distance r/R_{max}~0.3--0.5 of the stellar surface can produce the observed effects. Here, R_{max} is the extent of the N V line-forming region. The results are consistent either with a scenario in which the opacity of the inner wind region of HD 50896 undergoes cyclical variations over the 3.76 d period or with a quadrupolar wind distribution in which the sectors having different opacities rotate in and out of our line-of-sight on this periodic timescale.

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Computing the dust distribution in the bowshock of a fast moving, evolved star

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We study the hydrodynamical behavior occurring in the turbulent interaction zone of a fast moving red supergiant star, where the circumstellar and interstellar material collide. In this wind-interstellar medium collision, the familiar bow shock, contact discontinuity, and wind termination shock morphology forms, with localized instability development. Our model includes a detailed treatment of dust grains in the stellar wind, and takes into account the drag forces between dust and gas. The dust is treated as pressureless gas components binned per grainsize, for which we use ten representative grainsize bins. Our simulations allow to deduce how dust grains of varying sizes become distributed throughout the circumstellar medium. We show that smaller dust grains (radius <0.045 micro-meters) tend to be strongly bound to the gas and therefore follow the gas density distribution closely, with intricate finestructure due to essentially hydrodynamical instabilities at the wind-related contact discontinuity. Larger grains which are more resistant to drag forces are shown to have their own unique dust distribution, with progressive deviations from the gas morphology. Specifically, small dust grains stay entirely within the zone bound by shocked wind material. The large grains are capable of leaving the shocked wind layer, and can penetrate into the shocked or even unshocked interstellar medium. Depending on how the number of dust grains varies with grainsize, this should leave a clear imprint in infrared observations of bowshocks of red supergiants and other evolved stars.

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Investigating the X-ray emission from the massive WR+O binary WR~22 using 3D hydrodynamical models

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We examine the dependence of the wind-wind collision and subsequent X-ray emission from the massive WR+O star binary WR~22 on the acceleration of the stellar winds, radiative cooling, and orbital motion.

Three dimensional (3D) adaptive-mesh refinement (AMR) simulations are presented that include radiative driving, gravity, optically-thin radiative cooling, and orbital motion. Simulations were performed with instantaneously accelerated and radiatively driven stellar winds. Radiative transfer calculations were performed on the simulation output to generate synthetic X-ray data, which are used to conduct a detailed comparison against observations.

When instantaneously accelerated stellar winds are adopted in the simulation, a stable wind-wind collision region (WCR) is established at all orbital phases. In contrast, when the stellar winds are radiatively driven, and thus the acceleration regions of the winds are accounted for, the WCR is far more unstable. As the stars approach periastron, the ram pressure of the WR's wind overwhelms the O star's and, following a significant disruption of the shocks by non-linear thin-shell instabilities (NTSIs), the WCR collapses onto the O star. X-ray calculations reveal that when a stable WCR exists the models over-predict the observed X-ray flux by more than two orders of magnitude. The collapse of the WCR onto the O star substantially reduces the discrepancy in the $2-10;$keV flux to a factor of $simeq 6$ at $phi=0.994$. However, the observed spectrum is not well matched by the models.

We conclude that the agreement between the models and observations could be improved by increasing the ratio of the mass-loss rates in favour of the WR star to the extent that a normal wind ram pressure balance does not occur at any orbital phase, potentially leading to a sustained collapse of the WCR onto the O star. Radiative braking may then play a significant r^{o}le for the WCR dynamics and resulting X-ray emission.

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Hydrodynamic Interaction between the Be Star and the Pulsar in the TeV Binary PSR B1259-63/LS 2883

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We study the interaction between the Be star and the pulsar in the TeV binary PSR B1259-63/LS 2883, using 3-D SPH simulations of the tidal and wind interactions in this Be-pulsar system. We first run a simulation without pulsar wind nor Be wind, taking into account only the gravitational effect of the pulsar on the Be disk. In this simulation, the gas particles are ejected at a constant rate from the equatorial surface of the Be star, which is tilted in a direction consistent with multi-waveband observations. We run the simulation until the Be disk is fully developed and starts to repeat a regular tidal interaction with the

pulsar. Then, we turn on the pulsar wind and the Be wind. We run two simulations with different wind mass-loss rates for the Be star, one for a B2V type and the other for a significantly earlier spectral type. Although the global shape of the interaction surface between the pulsar wind and the Be wind agrees with the analytical solution, the effect of the pulsar wind on the Be disk is profound. The pulsar wind strips off an outer part of the Be disk, truncating the disk at a radius significantly smaller than the pulsar orbit. Our results, therefore, rule out the idea that the pulsar passes through the Be disk around periastron, which has been assumed in the previous studies. It also turns out that the location of the contact discontinuity can be significantly different between phases when the pulsar wind directly hits the Be disk and those when the pulsar wind collides with the Be wind. It is thus important to adequately take into account the circumstellar environment of the Be star, in order to construct a satisfactory model for this prototypical TeV binary.

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New Constraints on the Origin of the Short-Term Cyclical Variability of the Wolf-Rayet Star WR 46

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The Wolf-Rayet star WR 46 is known to exhibit a very complex variability pattern on relatively short time scales of a few hours. Periodic but intermittent radial velocity shifts of optical lines as well as multiple photometric periods have been found in the past. Non-radial pulsations, rapid rotational modulation or the presence of a putative low-mass companion have been proposed to explain the short-term behavior. In an effort to unveil its true nature, we observed WR 46 with the Far Ultraviolet Spectroscopic Explorer (FUSE) over several short-term variability cycles. We found significant variations on a timescale of ~8 hr in the far-ultraviolet (FUV) continuum, in the blue edge of the absorption trough of the O VI λλ1032,1038 doublet P Cygni profile and in the S VI λλ933,944 P Cygni absorption profile. We complemented these observations with X-ray and UV light-curves and an X-ray spectrum from archival X-ray Multi-Mirror Mission - Newton Space Telescope (XMM-Newton) data. The X-ray and UV light-curves show variations on a time scale similar to the variability found in the FUV. We discuss our results in the context of the different scenarios suggested to explain the short-term variability of this object and reiterate that non-radial pulsations is the most likely to occur.

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The VLT-FLAMES Tarantula Survey III: A very massive star in apparent isolation from the massive cluster R136

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VFTS 682 is located in an active star-forming region, at a projected distance of 29 pc from the young massive cluster R136 in the Tarantula Nebula of the Large Magellanic Cloud. It was previously reported as a candidate young stellar object, and more recently spectroscopically revealed as a hydrogen-rich Wolf-Rayet (WN5h) star. Our aim is to obtain the stellar properties, such as its intrinsic luminosity, and to investigate the origin of VFTS 682. To this purpose, we model optical spectra from the VLT-FLAMES Tarantula Survey with the non-LTE stellar atmosphere code CMFGEN, as well as the spectral energy distribution from complementary optical and infrared photometry. We find the extinction properties to be highly peculiar (RV ~4.7), and obtain a surprisingly high luminosity log(L/Lsun) = 6.5 pm 0.2, corresponding to a present-day mass of ~150Msun. The high effective temperature of 52.2 pm 2.5kK might be explained by chemically homogeneous evolution - suggested to be the key process in the path towards long gamma-ray bursts. Lightcurves of the object show variability at the 10% level on a timescale of years. Such changes are unprecedented for classical Wolf-Rayet stars, and are more reminiscent of Luminous Blue Variables. Finally, we discuss two possibilities for the origin of VFTS 682: (i) the star either formed in situ, which would have profound implications for the formation mechanism of massive stars, or (ii) VFTS 682 is a slow runaway star that originated from the dense cluster R136, which would make it the most massive runaway known to date.

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Spectral Classification of O2-3.5If*/WN5-7 stars

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An updated classification scheme for transition O2-3.5If*/WN5-7 stars is presented, following recent revisions to the spectral classifications for O and WN stars. We propose that O2-3.5If*, O2-3.5If*/WN5-7 and WN5-7 stars may be discriminated using the morphology of Hbeta to trace increasing wind density as follows: purely in absorption for O2-3.5If* stars in addition to the usual diagnostics from Walborn et al.; P Cygni for O2-3.5If*/WN5-7 stars; purely in emission for WN stars in addition to the usual diagnostics from Smith et al. We also discuss approximate criteria to discriminate between these subtypes from near-IR spectroscopy. The physical and wind properties of such stars are qualitatively discussed together with their evolutionary significance. We suggest that the majority of O2-3.5If*/WN5-7 stars are young, very massive hydrogen-burning stars, genuinely intermediate between O2-3.5If* and WN5-7 subtypes, although a minority are apparently core helium-burning stars evolving blueward towards the classical WN sequence. Finally, we reassess classifications for stars exhibiting lower ionization spectral features plus Hbeta emission.

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A Systematic Search for Corotating Interaction Regions in Apparently Single Galactic Wolf-Rayet Stars. II. A Global View of the Wind Variability

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This study is the second part of a survey searching for large-scale spectroscopic variability in apparently single Wolf-Rayet (WR) stars. In a previous paper (Paper I), we described and characterized the spectroscopic variability level of 25 WR stars observable from the northern hemisphere and found 3 new candidates presenting large-scale wind variability, potentially originating from large-scale structures named Co-rotating Interaction Regions (CIRs). In this second paper, we discuss an additional 39 stars observable from the southern hemisphere. For each star in our sample, we obtained 4-5 high-resolution spectra with a signal-to-noise ratio of ~100 and determined its variability level using the approach described in Paper I. In total, 10 new stars are found to show large-scale spectral variability of which 7 present CIR-type changes (WR 8, WR 44, WR 55, WR 58, WR 61, WR 63, WR 100). Of the remaining stars, 20 were found to show small-amplitude changes and 9 were found to show no spectral variability as far as can be concluded from the data in hand. Also, we discuss the spectroscopic variability level of all single galactic WR stars that are brighter than v~12.5, and some WR stars with 12.5 < v <= 13.5; i.e. all the stars presented in our two papers and 4 more stars for which spectra have already been published in the literature. We find that 23/68 stars (33.8 %) present large-scale variability, but only 12/54 stars (~22.1 %) are potentially of CIR-type. Also, we find 31/68 stars (45.6 %) that only show small-scale variability, most likely due to clumping in the wind. Finally, no spectral variability is detected based on the data in hand for 14/68 (20.6 %) stars. Interestingly, the variability with the highest amplitude also have the widest mean velocity dispersion.

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The non-thermal, time-variable radio emission from Cyg OB2 # 5: A wind-collision region

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The radio emission from the well-studied massive stellar system Cyg OB2 #5 is known to fluctuate with a period of 6.7 years between a low-flux state when the emission is entirely of free-free origin, and a high-flux state when an additional non-thermal component (of hitherto unknown nature) appears. In this paper, we demonstrate that the radio flux of that non-thermal component is steady on timescales of hours, and that its morphology is arc-like. This shows that the non-thermal emission results from the collision between the strong wind driven by the known contact binary in the system, and that of an unseen companion on a somewhat eccentric orbit with a 6.7-yr period and a 5 to 10 mas semi-major axis. Together with the previously reported wind-collision region located about 0.8" to the north-east of the contact binary, Cyg OB2 #5 appears to be the only multiple system known so far to harbor two radio-imaged wind-collision regions.

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Status: Manuscript has been accepted

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Red Eyes on Wolf-Rayet Stars: 60 New Discoveries via Infrared Color Selection

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We have spectroscopically identified 60 Galactic Wolf-Rayet stars (WRs), including 38 nitrogen types (WN) and 22 carbon types (WC). Using photometry from the textit{Spitzer}/GLIMPSE and Two-Micron All-Sky Survey (2MASS) databases, the new WRs were selected via a method we have established that exploits their unique infrared colors, which is mainly the result of excess radiation generated by free-free scattering within their dense ionized winds. The selection criterion has been refined since the last report, resulting in a WR detection rate of ~20% in spectroscopic follow-up of candidates that comprise a broad color space defined by the color distribution of all known WRs having B>14 mag. However, there are smaller regions within this color space which yield WRs at a rate of >50% in spectroscopic follow-up. Candidates which are not WRs are mainly Be stars, which is possibly attributable to the physical similarities between the free-free emission parameters of Be disks and WR winds. As an additional selection experiment, the list of WR candidates was cross-correlated with archival X-ray point-source catalogs, which increases the WR detection rate of the broad color space to ~40%; ten new WR X-ray sources have been found, in addition to a previously unrecognized X-ray counterpart to a known WR. The extinction values, distances, and galactocentric radii of all new WRs are calculated using the method of spectroscopic parallax. Although the majority of the new WRs have no obvious association with stellar clusters, two WC8 stars reside in a previously unknown massive-star cluster, in which five OB supergiants were also identified. The new system lies at an estimated distance of ~6.1 kpc, near the intersection of the Scutum-Centaurus Arm with the Galaxy's bar. In addition, two WC and four WN stars, all but one of which are X-ray sources, were identified in association with the stellar clusters Danks 1 and 2. A WN9 star has also been associated with the cluster [DBS2003] 179. This work brings the total number of known Galactic WRs to 476, or ~7-8% of the total empirically estimated population. An examination of their Galactic distribution reveals an approximate tracing of the major spiral arms and an enhanced WR surface density toward major, massive-star formation sites.

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Slow Radiation-Driven Wind Solutions of A-Type Supergiants

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The theory of radiation-driven winds succeeded in describing terminal velocities and mass loss rates of massive stars. However, for A-type supergiants the standard m-CAK solution predicts values of mass loss and terminal velocity higher than the observed values. Based on the existence of a slow wind solution in fast rotating massive stars, we explore numerically the parameter space of radiation-driven flows to search for new wind solutions in slowly rotating stars, that could explain the origin of these discrepancies. We solve the 1-D hydrodynamical equation of rotating radiation-driven winds at different stellar latitudes and explore the influence of ionization's changes throughout the wind in the velocity profile. We have found that for particular sets of stellar and line-force parameters, a new slow solution exists over the entire star when the rotational speed is slow or even zero. In the case of slow rotating A-type supergiant stars the presence of this novel slow solution at all latitudes leads to mass losses and wind terminal velocities which are in agreement with the observed values. The theoretical Wind Momentum-Luminosity Relationship derived with these slow solutions shows very good agreement with the empirical relationship. In addition, the ratio between the terminal and escape velocities, which provides a simple way to predict stellar wind energy and momentum input into the interstellar medium, is also properly traced.

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Drastic Spectroscopic Variability of the Be/X-ray Binary A0535+262/V725 Tau during and after the 2009 Giant Outburst

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We report on high-dispersion optical spectroscopic observations of the Be/X-ray binary A0535+262/V725 Tau during the giant outburst in November/December 2009 and after it. The observed emission line profiles, reflecting the structure of the geometrically thin circumstellar envelope of the Be star (Be disk), show drastic variabilities and indicate the existence of a warped component. The enhanced

blue shoulder seen after periastron passage implies the gas stream from a dense part of the Be disk to the neutron star.

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Early magnetic B-type stars: X-ray emission and wind properties

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We present a comprehensive study of X-ray emission and wind properties of massive magnetic early B-type stars. Dedicated XMM-Newton observations were obtained for three stars xi1 CMa, V2052 Oph, and zeta Cas. We report the first detection of X-ray emission from V2052 Oph and zeta Cas. The observations show that the X-ray spectra of our program stars are quite soft. We compile the complete sample of early B-type stars with detected magnetic fields to date and existing X-ray measurements, in order to study whether the X-ray emission can be used as a general proxy for stellar magnetism. We find that hard and strong X-ray emission does not necessarily correlate with the presence of a magnetic field. We analyze the UV spectra of five non-supergiant B stars with magnetic fields by means of non-LTE iron-blanketed model atmospheres. The latter are calculated with the PoWR code, which treats the photosphere as well as the the wind, and also accounts for X-rays. Our models accurately fit the stellar photospheric spectra in the optical and the UV. The parameters of X-ray emission, temperature and flux are included in the model in accordance with observations. We confirm the earlier findings that the filling factors of X-ray emitting material are very high. Our analysis reveals that the magnetic early type B stars studied here have weak winds. The mass-loss rates are significantly lower than predicted by hydrodynamically consistent models. We find that, although the X-rays strongly affect the ionization structure of the wind, this effect is not sufficient in reducing the total radiative acceleration. When the X-rays are accounted for at the intensity and temperatures observed, there is still sufficient radiative acceleration to drive stronger mass-loss than we empirically infer from the UV spectral lines. (abridged)

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Penetrating the Homunculus, Near-Infrared Adaptive Optics Images of Eta Carinae

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Near-infrared adaptive optics imaging with the Near-Infrared Coronagraphic Imager (NICI) and NaCO reveal what appears to be a three-winged or lobed pattern, the "butterfly nebula," outlined by bright Brγ and H2 emission and light scattered by dust. In contrast, the [Fe II] emission does not follow the outline of the wings, but shows an extended bipolar distribution which is tracing the Little Homunculus ejected in η Car's second or lesser eruption in the 1890s. Proper motions measured from the combined NICI and NaCO images together with radial velocities show that the knots and filaments that define the bright rims of the butterfly were ejected at two different epochs corresponding approximately to the great eruption and the second eruption. Most of the material is spatially distributed 10°-20° above and below the equatorial plane apparently behind the Little Homunculus and the larger SE lobe. The equatorial debris either has a wide opening angle or the clumps were ejected at different latitudes relative to the plane. The butterfly is not a coherent physical structure or equatorial torus but spatially separate clumps and filaments ejected at different times, and now 2000-4000 AU from the star.

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On the nature of the prototype LBV AG Carinae II. Witnessing a massive star evolving close to the Eddington and bistability limits

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We show that the significantly different effective temperatures (Teff) achieved by the luminous blue variable AG Carinae during the consecutive visual minima of 1985-1990 (Teff= 22,800 K) and 2000-2001 (Teff=17,000 K) place the star on different sides of the bistability limit, which occurs in line-driven stellar winds around Teff ~ 21,000 K. Decisive evidence is provided by huge changes in the optical depth of the Lyman continuum in the inner wind as Teff changes during the S Dor cycle. These changes cause different Fe ionization structures in the inner wind. The bistability mechanism is also related to the

different wind parameters during visual minima: the wind terminal velocity was 2-3 times higher and the mass-loss rate roughly two times smaller in 1985-1990 than in 2000-2003. We obtain a projected rotational velocity of 220 +- 50 km/s during 1985-1990 which, combined with the high luminosity (L=1.5x10^6 Lsun), puts AG Car extremely close to the Eddington limit modified by rotation (Omega-Gamma limit): for an inclination angle of 90 deg, Gamma_Omega > 1.0 for M< 60 Msun. Based on evolutionary models and mass budget, we obtain an initial mass of ~ 100 Msun and a current mass of 60-70 Msun for AG Car. Therefore, AG Car is close to, if not at, the Omega-Gamma limit during visual minimum. Assuming M=70 Msun, we find that Gamma_Omega decreases from 0.93 to 0.72 as AG Car expands toward visual maximum, suggesting that the star is not above the Eddington limit during maximum phases.

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The Stellar Content of Obscured Galactic Giant HII Regions. VII. W3

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Spectrophotometric distances in the K band have been reported by different authors for a number of obscured Galactic HII regions. Almost 50% of them show large discrepancies compared to the classical method using radial velocities measured in the radio spectral region. In order to provide a crucial test of both methods, we selected a target which does not present particular difficulty for any method and which has been measured by as many techniques as possible. The W3 star forming complex, located in the Perseus arm, offers a splendid opportunity for such a task. We used the NIFS spectrograph on the Frederick C. Gillett Gemini North telescope to classify candidate "naked photosphere" OB stars based on 2MASS photometry. Two of the targets are revealed to be mid O-type main sequence stars leading to a distance of d = 2.20 kpc. This is in excellent agreement with the spectrophotometric distance derived in the optical band (d = 2.18 kpc, Humphreys 1978) and with a measurement of the W3 trigonometric parallax (d = 1.95 kpc, Xu et al. 2006). Such results confirm that the spectrophotometric distances in the K band are reliable. The radio derived kinematic distance, on the contrary, gives a distance twice as large (d = 4.2 kpc, Russeil 2003). This indicates that this region of Perseus arm does not follow the Galactic rotation curve, and this may be the case also for other HII regions for which discrepancies have been found.

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Resolved photometry of extragalactic young massive star clusters

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We present colour-magnitude diagrams (CMDs) for a sample of seven young massive clusters in the galaxies NGC 1313, NGC 1569, NGC 1705 and NGC 5236. The clusters have ages in the range 5-50 million years and masses of 10^5 -10^6 M_odot. Although crowding prevents us from obtaining photometry in the inner regions of the clusters, we are still able to measure up to 30-100 supergiant stars in each of the richest clusters, along with the brighter main sequence stars. The resulting CMDs and luminosity functions are compared with photometry of artificially generated clusters, designed to reproduce the photometric errors and completeness as realistically as possible. In agreement with previous studies, our CMDs show no clear gap between the H-burning main sequence and the He-burning supergiant stars, contrary to predictions by common stellar isochrones. In general, the isochrones also fail to match the observed number ratios of red-to-blue supergiant stars, although the difficulty of separating blue supergiants from the main sequence complicates this comparison. In several cases we observe a large spread (1-2 mag) in the luminosities of the supergiant stars that cannot be accounted for by observational errors. This spread can be reproduced by including an age spread of 10-30 million years in the models. However, age spreads cannot fully account for the observed morphology of the CMDs and other processes, such as the evolution of interacting binary stars, may also play a role.

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