THE MASSIVE STAR NEWSLETTER

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Contents of this newsletter

Working group matters 1

Abstracts of 11 accepted papers 2

Abstracts of 1 submitted paper 8

Abstracts of 1 proceedings paper 9

Abstract of 1 dissertation thesis 9

Jobs 11

Working Group Matters

Raphael Hirschi Accepts Website Manager Position

Claus Leitherer, on behalf of the OC

The OC welcomes Dr. Raphael Hirschi (Univ. of Basel) as the new manager of our Massive Star website. Raphael has multi-year experience in the developement and management of websites. He is thrilled to provide his expertise for the improvement of our site, which continues to be hosted at UNAM. Raphael's scientific interests are in the field of massive star evolution.

He can be contacted at

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Membership Directory

Raphael Hirschi, University of Basel

Dear Massive Star researchers,

You are kindly asked to update or enter your details in the member directory:
http://www.astroscu.unam.mx/massive_stars/members/members.php

Most people already have an entry that they can update. The others were not on the list i had at the time of the creation of the member directory.

Once your details are updated, i will remove the old details. Note that the @ symbol of your email address will not appear on the web page.

Send me an email if you have problems: raphael.hirschi@unibas.ch

Best regards

Raphael (Webmaster)

Accepted Papers

The massive binary CPD - 41 7742 II. Optical light curve and X-ray observations

H. Sana, E. Antokhina, P. Royer, J. Manfroid, E. Gosset, G. Rauw and J.-M. Vreux

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In the first paper of this series, we presented a detailed high-resolution spectroscopic study of CPD - 41 7742 , deriving for the first time an orbital solution for both components of the system. In this second paper, we focus on the analysis of the optical light curve and on recent XMM-Newton X-ray observations. In the optical, the system presents two eclipses, yielding an inclination i $\sim$ 77 deg. Combining the constraints from the photometry with the results of our previous work, we derive the absolute parameters of the system. We confirm that the two components of CPD - 41 7742 are main sequence stars (O9 V + B1-1.5 V) with masses ($M_1 \sim 18$ Msol and $M_2 \sim 10$ Msol) and respective radii ($R_1 \sim 7.5$ Rsol and $R_2 \sim 5.4$ Rsol) close to the typical values expected for such stars.

We also report an unprecedented set of X-ray observations that almost uniformly cover the 2.44-day orbital cycle. The X-ray emission from CPD - 41M-0 7742 is well described by a two-temperature thermal plasma model with energies close to 0.6 and 1.0 keV, thus slightly harder than typical early-type emission. The X-ray light curve shows clear signs of variability. The emission level is higher when the primary is in front of the secondary. During the high emission state, the system shows a drop of its X-ray emission that almost exactly matches the optical eclipse. We interpret the main features of the X-ray light curve as the signature of a wind-photosphere interaction, in which the overwhelming primary O9 star wind crashes into the secondary surface. Alternatively the light curve could result from a wind-wind interaction zone located near the secondary star surface. As a support to our interpretation, we provide a phenomenological geometric model that qualitatively reproduces the observed modulations of the X-ray emission.

Reference: A&A 441, 213-229 (2005)

Weblink: http://vela.astro.ulg.ac.be/Preprints/P102/index.html

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The LMC HII region N 214C and its peculiar nebular blob

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We study the Large Magellanic Cloud HII region N 214C using imaging and spectroscopy obtained at the ESO New Technology Telescope. On the basis of the highest resolution images so far obtained of the OB association LH 110, we show that the main exciting source of the HII region, Sk -7151, is in fact a tight cluster of massive stars consisting of at least 6 components in an area $\sim$ 4" wide. Spectroscopic observations allow us to revise the spectral type of the main component (#17) to O2 V ((f*)) + OB, a very rare, hot type. We also classify several other stars associated with N 214C and study the extinction and excitation characteristics of the HII region. Moreover, we obtain BVR photometry and astrometry of 2365 stars and from the corresponding color-magnitude diagram study the stellar content of N 214C and the surrounding LH 110. Furthermore, we discover a striking compact blob of ionized gas in the outer northern part of N 214C. A spherical structure of $\sim$ 5", in radius ($\sim$ 1.3 pc), it is split into two lobes by absorbing dust running diametrically through its center. We discuss the possible nature of this object.

Reference: Astronomy & Astrophysics, 2005, 436, 117

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Stellar evolution with rotation and magnetic fields:III: The interplay of circulation and dynamo

André Maeder, Georges Meynet

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We examine the effects of the magnetic field created by the Tayler–Spruit dynamo in differentially rotating stars. Magnetic fields of the order of a few 10^4 G are present through most of the stellar envelope, with the exception of the outer layers. The diffusion coefficient for the transport of angular momentum is very large and it imposes nearly solid body rotation during the MS phase. In turn, solid body rotation drives meridional circulation currents which are much faster than usual and leads to much larger diffusion coefficients than the magnetic diffusivity for the chemical species. The consequence is that the interplay of the thermal and magnetic instabilities favours the chemical transport of elements, while there would be no transport in models with magnetic field only. We also discuss the effects on the stellar interior, lifetimes and HR diagram.

Reference: Astronomy & Astrophysics, in press

Weblink: http://xxx.uni-augsburg.de/abs/astro-ph/0506347

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A Spectroscopic Search for the non-nuclear Wolf-Rayet Population of the metal-rich spiral galaxy M83

Lucy Hadfield (1), Paul Crowther (1), Hans Schild (2), Werner Schmutz (3)

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We present a catalogue of non-nuclear regions containing Wolf-Rayet stars in the metal-rich spiral galaxy M83 (NGC5236). From a total of 283 candidate regions identified using HeII 4686 imaging with VLT-FORS2, Multi Object Spectroscopy of 198 regions was carried out, confirming 132 WR sources. From this sub-sample, an exceptional content of 1035 +/- 300 WR stars is inferred, with N(WC)/N(WN) approx 1.2, continuing the trend to larger values at higher metallicity amongst Local Group galaxies, and greatly exceeding current evolutionary predictions at high metallicity. Late-type stars dominate the WC population of M83, with N(WC8-9)/N(WC4-7)=9 and WO subtypes absent, consistent with metallicity dependent WC winds. Equal numbers of late to early WN stars are observed, again in contrast to current evolutionary predictions. Several sources contain large numbers of WR stars. In particular, #74 (alias region 35 from De Vaucouleurs et al. contains 230 WR stars, and is identified as a Super Star Cluster from inspection of archival HST/ACS images. Omitting this starburst cluster would result in revised statistics of N(WC)/N(WN) approx 1 and N(WC8-9)/N(WC4-7) approx 6 for the 'quiescent' disk population. Including recent results for the nucleus and accounting for incompleteness in our spectroscopic sample, we suspect the total WR population of M83 may exceed 3000 stars.

Reference: A&A in press

Weblink: http://arxiv.org/abs/astro-ph/0506343

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On the origin of the X-ray emission towards the early Herbig Be star MWC 297

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We present high resolution AO-corrected coronographic near-infrared imaging on the early-type Herbig Be star MWC 297. X-ray flaring has been reported towards this young object, however this has been difficult to reconcile with its early spectral type (B1.5) and relatively high mass (10 – 15 Msun). Our infrared and X-ray analysis shows that the X-ray flaring is likely due to a late-type star in the same field. The case of MWC 297 emphasizes the need for coronographic imaging to address the reality of X-ray emission towards Herbig Ae/Be stars, which is needed to understand the differences between low and high-mass star formation.

Reference: A&A Letters

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The sub-arcsecond dusty environment of Eta Carinae

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The core of the nebula surrounding Eta Carinae has been observed with the VLT Adaptive Optics system NACO and with the interferometer VLTI/MIDI to constrain spatially and spectrally the warm dusty environment and the central object. In particular, narrow-band images at 3.74 and 4.05 micron reveal the butterfly shaped dusty environment close to the central star with unprecedented spatial resolution. A void whose radius corresponds to the expected sublimation radius has been discovered around the central source. Fringes have been obtained in the Mid-IR which reveal a correlated flux of about 100 Jy situated 0.3" south-east of the photocenter of the nebula at 8.7 micron, which corresponds with the location of the star as seen in other wavelengths. This correlated flux is partly attributed to the central object, and these observations provide an upper limit for the SED of the central source from 2.2 to 13.5 micron. Moreover, we have been able to spectrally disperse the signal from the nebula itself at PA=318 degree, i.e. in the direction of the bipolar nebula (310 degree) within the MIDI field of view of 3 arcsec. A large amount of corundum (Al2O3) is discovered, peaking at 0.6-1.2 arcsec south-east from the star, whereas the dust content of the Weigelt blobs is dominated by silicates. We discuss the mechanisms of dust formation which are closely related to the geometry of this Butterfly nebulae.

Reference: 2005, A&A, 435, 1043

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The enigmatic B[e]-star Henize 2-90: The non-spherical mass loss history from an analysis of forbidden lines

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(abridged) We study the optical spectrum of the exciting B[e] star Hen 2-90 based on new high-resolution observations that cover the innermost $2''$. Our investigation is splitted in two parts, a qualitative study of the presence of the numerous emission lines and the classification of their line profiles which indicate a circumstellar environment of high complexity, and a quantitative analysis of numerous forbidden lines, e.g. [OI], [OII], [OIII], [SII], [SIII], [ArIII], [ClII], [ClIII] and [NII]. We find a correlation between the different ionization states of the elements and the velocities derived from the line profiles: the highly ionized atoms have the highest outflow velocity while the neutral lines have the lowest outflow velocity. The recent HST image of Hen 2-90 reveals a bipolar, highly ionized region, a neutral disk-like structure and an intermediate region of moderate ionization. It seems that a non-spherical stellar wind model is a good option to explain the ionization and spatial distribution of

the circumstellar material. We modelled the forbidden lines under the assumption of a non-spherically symmetric wind based on the HST image. We find that in order to fit the observed line luminosities, the mass flux, surface temperature, and terminal wind velocities need to be latitude dependent, which might be explained in terms of a rapidly rotating central star. A rotation speed of 75-80% of the critical velocity has been derived. The total mass loss rate of the star was determined to be of order $3 \times 10^{-5}\,M_{\odot}yr^{-1}$. Such a wind scenario and the fact that compared to solar abundances C, O, and N seem to be underabundant while S, Ar and Cl have solar abundances, might be explained in terms of a rapidly rotating post-AGB star.

Reference: Accepted by A&A

Weblink: http://arxiv.org/abs/astro-ph/0505203

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Evolution of X-ray emission from young massive star clusters

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The evolution of X-ray emission from young massive star clusters is modeled, taking into account the emission from the stars as well as from the cluster wind. It is shown that the level and character of the soft (0.2-10 keV) X-ray emission change drastically with cluster age and are tightly linked with stellar evolution. Using the modern X-ray observations of massive stars we show that the correlation between bolometric and X-ray luminosity known for single O stars also holds for O+O and O+Wolf-Rayet (WR) binaries. We find no evidence of WN8 type stars being X-ray sources. The diffuse emission originates from the cluster wind heated by the kinetic energy of stellar winds and supernova explosions. To model the evolution of the cluster wind, the mass and energy yields from a population synthesis are used as input to a hydrodynamic model. It is shown that in a very young clusters the emission from the cluster wind is low. When the cluster evolves, WR stars are formed. Their strong stellar winds power an increasing X-ray emission of the cluster wind. Subsequent supernova explosions pump the level of diffuse emission even higher. Clusters at this evolutionary stage may have no X-ray bright stellar point sources, but a relatively high level of diffuse emission. A supernova remnant may become a dominant X-ray source, but only for a short time interval of a few thousand years. We retrieve and analyse Chandra and XMM-Newton observations of six massive star clusters located in the Large Magellanic Cloud. Our model reproduces the observed diffuse and point-source emission from these LMC clusters, as well as from the Galactic clusters Arches, Quintuplet and NGC 3603.

Reference: MNRAS

Weblink: astro-ph/0505512

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Effects of gravitational darkening on the determination of fundamental parameters in fast rotating B-type stars

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In this paper we develop a calculation code to account for the effects carried by fast rotation on the observed spectra of early-type stars. Stars are assumed to be in rigid rotation, and the grid of plane-parallel model atmospheres used to represent the gravitational darkening are calculated by means of a non-LTE approach. Attention is paid to the relation between the apparent and parent non-rotating counterpart stellar fundamental parameters and apparent, and true V sin i parameters as a function of the rotation rate Omega/Omega_c, stellar mass, and inclination angle. It is shown that omitting of gravitational darkening in the analysis of chemical abundances of CNO elements can produce systematic overestimation or underestimation, depending on the lines used, rotational rate, and inclination angle. The proximity of Be stars to the critical rotation is revised while correcting not only the V sin i of 130 Be stars, but also their effective temperature and gravity to account for stellar rotationally induced geometrical distortion and for the concomitant gravitational darkening effect. We concluded that the V sin i increase is accompanied by an even higher value for the stellar equatorial critical velocity, so that the most probable average rate of the angular velocity of Be stars attains Omega/Omega_c $\sim$ 0.88.

Reference: A&A

Weblink: http://arxiv.org/abs/astro-ph/0503381

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Asphericity and clumpiness in the winds of Luminous Blue Variables

Ben Davies (1), Rene D. Oudmaijer (1), Jorick S. Vink (2)

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We present the first systematic spectropolarimetric study of Luminous Blue Variables (LBVs) in the Galaxy and the Magellanic Clouds, in order to investigate the geometries of their winds. We find that at least half of our sample show changes in polarization across the strong Hα emission line, indicating that the light from the stars is intrinsically polarized and therefore that asphericity already exists at the base of the wind. Multi-epoch spectropolarimetry on four targets reveals variability in their intrinsic polarization. Three of these, AG Car, HR Car and P Cyg, show a position angle (PA) of polarization which appears random with time. Such behaviour can be explained by the presence of strong wind-inhomogeneities, or 'clumps' within the wind. Only one star, R 127, shows variability at a constant PA, and hence evidence for axi-symmetry as well as clumpiness. However, if viewed at low inclination, and at limited temporal sampling, such a wind would produce a seemingly random polarization of the type observed in the other three stars. Time-resolved spectropolarimetric monitoring of LBVs is therefore required to determine if LBV winds are axi-symmetric in general. The high fraction of LBVs (>50%) showing intrinsic polarization is to be compared with the lower $\sim$20-25% for similar studies of their evolutionary neighbours, O supergiants and Wolf-Rayet stars. We anticipate that this higher incidence is due to the lower effective gravities of the LBVs, coupled with their variable temperatures within the bi-stability jump regime. This is also consistent with the higher incidence of wind asphericity that we find in LBVs with strong Hα emission and recent (last $\sim$10 years) strong variability.

Reference: A&A, accepted

Weblink: http://arxiv.org/abs/astro-ph/0505344

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Numerical biases on IMF determinations created by binning

J. Maíz-Apellániz & L. Úbeda

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We detect and quantify significant numerical biases in the determination of the slope of power laws with Salpeter (or similar) indices from uniformly-binned data using chi-square minimization. The biases are caused by the correlation between the number of stars per bin and the assigned weights and are especially important when the number of stars per bin is small. This result implies the existence of systematic errors in the values of IMFs calculated in this way. We propose as an alternative using variable-size bins and dividing the stars evenly among them. Such variable-size bins yield very small biases that are only weakly dependent on the number of stars per bin. Furthermore, we show that they allow for the calculation of reliable IMFs with only a small total number of stars. Therefore, they are a preferred alternative to the standard uniform-size binning.

Reference: To appear in the 20 August 2005 issue of ApJ

Weblink: http://www.stsci.edu/∼jmaiz

Comments: Also available from astro-ph/0505012

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Submitted Papers

Kappa-mechanism excitation of retrograde mixed modes in rotating B-type stars

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I examine the stability of retrograde mixed modes in rotating B-type stars. These modes can be regarded as a hybridization between the Rossby modes that arise from conservation of vorticity, and the Poincaré modes that are gravity waves modified by the Coriolis force. Using a non-adiabatic pulsation code based around the traditional approximation, I find that the modes are unstable in mid- to late-B type stars, due to the same iron-bump opacity mechanism usually associated with SPB and β Cep stars. At one half of the critical rotation rate, the instability for $m = 1 \ldots 4$ modes spans the spectral types B4 to A0. Inertial-frame periods of the unstable modes range from 100 days down to a fraction of a day, while normalized growth rates can reach in excess of 10^{-5}.

I discuss the relevance of these findings to the mass-loss mechanism of Be stars, and to the pulsation of the putative Maia class of variable star. I also outline some of the questions raised by this discovery of a wholly-new class of pulsational instability in early-type stars.

Reference: MNRAS

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

Comments: 10 pages, 6 figures

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In Proceedings

Metals in Star-Forming Galaxies at High Redshift

Claus Leitherer

Space Telescope Science Institute

The chemical composition of high-redshift galaxies is an important property that gives clues to their past history and future evolution. Measuring abundances in distant galaxies with current techniques is often a challenge, and the canonical metallicity indicators can often not be applied. I discuss currently available metallicity indicators based on stellar and interstellar absorption and emission lines, and assess their limitations and systematic uncertainties. Recent studies suggest that star-forming galaxies at redshift around 3 have heavy-element abundances already close to solar, in agreement with predictions from cosmological models.

Reference: IAU Symp. 228, From Lithium to Uranium, ed. V. Hill, P. Francois, & F. Primas (Cambridge: CUP), in press

Weblink: http://www.stsci.edu/science/starburst/Preprints/Leitherer_Paris05.pdf

Comments: Invited talk at IAU Symp. 228, Paris, May 2005

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Theses

New atmosphere models for massive stars: line-blanketing effects and wind properties of O stars

Fabrice Martins
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Massive stars are at a cornerstone of modern astrophysics. Their nucleosynthesis produces the elements heavier than Oxygen which are spread in the interstellar medium when they end their life as supernovae. They also emit high energy photons which ionise the surrounding medium, creating HII regions. They continuously emit powerful winds which interact with the interstellar medium, giving birth to bubbles, cavities and triggering the collapse of molecular clouds. The very first massive stars (the so-called population III stars) are also thought to be the precursors of gamma-ray bursts and may be responsible for the reionisation of the Universe at high redshift. Understanding quantitatively these objects is then crucial for a number of astrophysical studies. This requires the development of complex evolutionary models to explain the structure of their interior and their nucleosynthesis. And atmosphere models are necessary to make the link between the interior of the star and the observable quantities, and to constrain the stellar and wind properties of massive stars.

This thesis focuses on the second kind of models. The main reason is that significant progress has been made in the modelling of massive stars atmospheres in the last few years. In particular, it is

now possible to include reliably metals in such models. This allows the production of realistic models and synthetic spectra which can be used to improve our knowledge of the stellar and wind properties. In this thesis, we have built such new atmosphere models computed mainly with the code CMFGEN (Hillier & Miller 1998).

The first part of this work has been devoted to the analysis of the effects of the inclusion of metals in atmosphere models (the line-blanketing effects). We have confirmed the expected fact that both the atmospheric structure and the emergent spectrum are modified by the presence of metals. The temperature is increased in the interior of the atmosphere (backwarming effect) and reduced in the outer layers (line-cooling effect). The ionisation is also higher in the interior and lower in the upper atmosphere. This change of ionisation modifies the strength of He lines used for the spectral classification compared to models without metals, lowering the effective temperature scale of O dwarfs by 1500 (4000) K for late (early) type O dwarfs with solar abundances. For a lower metallicity typical of the Small Magellanic Cloud, the reduction of the $T_{\rm eff}$ - scale is roughly half that of the solar case. We also investigate the effect of line-blanketing on the spectral energy distribution of O stars. In particular, a study of compact Galactic HII regions observed in the mid-IR by ISO reveals that the new generation of atmosphere models allows a better, although not perfect, reproduction of the excitation sequences defined by ratios of nebular lines of the same element emitted in the HII region.

The second part of this thesis is devoted to the study of wind properties of dwarf O stars thanks to new atmosphere models. We first focus on the stellar components of the High Excitation Blob N81 in the Small Magellanic Cloud. The quantitative spectroscopic analysis of UV STIS spectra reveals that these stars are young O dwarfs with lower luminosities than typical O stars of the same spectral type and showing very weak winds. These characteristics may indicate that they belong to the class of Vz stars, a class of O stars thought to lie close to the ZAMS. With mass loss rates of the order of $10^{-8..-9}$ $M_\odot$ yr^{-1}, the winds are weaker than ever observed for such stars, and are weaker by 1 to 2 orders of magnitude compared to the predictions of hydrodynamical simulations. The modified wind momenta show the same trend, indicating possibly a break-down of the modified wind momentum - luminosity relation (WLR) or a steeper slope at lower metallicity. Different hypothesis are investigated to explain this strange behaviour (low metallicity, decoupling, line strength parameterisation in hydrodynamical simulations) without success. A possible link between the youth of the star and the weakness of developing winds may possibly explain such a behaviour. To better understand the conditions under which weak winds appear, we then analyse a sample of Galactic stars known to display qualitatively weak winds. Mass loss rates as low as $10^{-9.5}$ $M_\odot$ yr^{-1} are found in the faintest stars, showing that metallicity is not the main reason for the reduction of the wind strength. The break-down of the WLR around $\log \frac{L}{L_\odot} = 5.2$ seems to be confirmed. Bright stars also show winds slightly reduced compared to previous analysis due to the inclusion of clumping in the models. However, the reason for the reduced wind strength in low luminosity stars remains unknown.

Reference: Martins, F., 2004, PhD Thesis, Université Paul Sabatier, Toulouse, France

Weblink: http://www.mpe.mpg.de/~martins/pub/thesis_Fabrice_Martins.pdf

Comments: PhD thesis. Supervisor: Daniel Schaerer. Co-supervisor: Mohammad Heydari-Malayeri

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Jobs

Predoctoral Research Assistant

Schuyler Van Dyk

Spitzer Science Center/Caltech 1200 E. California Blvd. MS 220-6 Pasadena, CA 91125 USA Tel: 626-395-1881

A predoctoral research fellowship for one year is available at the Spitzer Science Center located on the California Institute of Technology campus in Pasadena, California, USA. The successful applicant will work with Drs. Schuyler Van Dyk and Patrick Morris to locate new, hidden Wolf-Rayet stars in the Milky Way using archival data obtained with the Spitzer Space Telescope. The fellow will also assist with follow-up spectroscopic observations of candidate stars using the Palomar 5-m and other large telescopes and help to write up results of the research for a refereed journal. The applicant can be at any stage of their graduate career. The research can be part of a thesis already underway elsewhere or be a completely independent research project. It is desirable that the applicant have an interest in stellar and infrared astronomy, and particularly in massive stellar evolution, with some experience in photometry, although these qualifications are not required. Applicants should submit a curriculum vitae, list of publications, and names of and contact information for two references to Dr. Van Dyk at the above address, or at vandyk@ipac.caltech.edu, by 2005 Aug 1 to receive full consideration.

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