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formely known as the hot star newsletter

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Post-doctoral Position at the University of São Paulo, Brazil

PAPERS

Abstracts of 12 accepted papers

Yellow Supergiants in the Small Magellanic Cloud (SMC): Putting Current Evolutionary Theory to the Test

Kathryn F. Neugent, Philip Massey, Brian Skiff, Maria R. Drout, Georges Meynet, Knut A. G. Olsen

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The yellow supergiant content of nearby galaxies provides a critical test of massive star evolutionary theory. While these stars are the brightest in a galaxy, they are difficult to identify because a large number of foreground Milky Way stars have similar colors and magnitudes. We previously conducted a census of yellow supergiants within M31 and found that the evolutionary tracks predict a yellow supergiant duration an order of magnitude longer than we observed. Here we turn our attention to the SMC, where the metallicity is 10× lower than that of M31, which is important as metallicity strongly affects massive star evolution. The SMC's large radial velocity (∼160 km s−1) allows us to separate members from foreground stars. Observations of ∼500 candidates yielded 176 near-certain SMC supergiants, 16 possible SMC supergiants, along with 306 foreground stars and provide good relative numbers of yellow supergiants down to 12M⊙. Of the 176 near-certain SMC supergiants, the kinematics predicted by the Besancon model of the Milky Way suggest a foreground contamination of ≤4%. After placing the SMC supergiants on the H-R diagram and comparing our results to the Geneva evolutionary tracks, we find results similar to those of the M31 study: while the locations of the stars on the H-R diagram match the locations of evolutionary tracks well, the models over-predict the yellow supergiant lifetime by a factor of ten. Uncertainties about the mass-loss rates on the main-sequence thus cannot be the primary problem with the models.

Reference: ApJ
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1006.5742

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Is Eta Carinae a fast rotator, and how much does the companion influence the inner wind structure?

Jose H. Groh (1), Thomas I. Madura (2), Stanley P. Owocki (2), D. John Hillier (3), Gerd Weigelt (1)

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We analyze interferometric measurements of the Luminous Blue Variable Eta Carinae with the goal of constraining the rotational velocity of the primary star and probing the influence of the companion. Using 2-D radiative transfer models of latitude-dependent stellar winds, we find that prolate wind models with a ratio of the rotational velocity (vrot) to the critical velocity (vcrit) of W=0.77-0.92, inclination angle of i=60-90 degrees, and position angle PA=108-142 degrees reproduce simultaneously K-band continuum visibilities from VLTI/VINCI and closure phase measurements from VLTI/AMBER. Interestingly, oblate models with W=0.73-0.90 and i=80-90 degrees produce similar fits to the interferometric data, but require PA=210-230 degrees. Therefore, both prolate and oblate models suggest that the rotation axis of the primary star is not aligned with the Homunculus polar axis. We also compute radiative transfer models of the primary star allowing for the presence of a cavity and dense wind-wind interaction region created by the companion star. We find that the wind-wind interaction has a significant effect on the K-band image mainly via free-free emission from the compressed walls and, for reasonable model parameters, can reproduce the VLTI/VINCI visibilities taken at phase 0.92-0.93. We conclude that the density structure of the primary wind can be sufficiently disturbed by the companion, thus mimicking the effects of fast rotation in the interferometric observables. Therefore, fast rotation may not be the only explanation for the interferometric observations. Intense temporal monitoring and 3-D modeling are needed to resolve these issues.

Reference: Groh et al. 2010, ApJL 716, L223
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1006.4816

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Spitzer SAGE-SMC Infrared Photometry of Massive Stars in the Small Magellanic Cloud

A. Z. Bonanos (1), D. J. Lennon (2,3), F. Köhlinger (4), J. Th. van Loon (5), D. L. Massa (2), M. Sewilo (2), C. J. Evans (6), N. Panagia (2,7,8), B. L. Babler (9), M. Block (10), S. Bracker (9), C. W. Engelbracht (9), K. D. Gordon (2), J. L. Hora (11), R. Indebetouw (12), M. R. Meade (9), M. Meixner (2), K. A. Misselt (10), T. P. Robitaille (11), B. Shiao (2) and B. A. Whitney (13)

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We present a catalog of 5324 massive stars in the Small Magellanic Cloud (SMC), with accurate spectral types compiled from the literature, and a photometric catalog for a subset of 3654 of these stars, with the goal of exploring their infrared properties. The photometric catalog consists of stars with infrared counterparts in the Spitzer, SAGE-SMC survey database, for which we present uniform photometry from 0.3-24 um in the UBVIJHKs+IRAC+MIPS24 bands. We compare the color magnitude diagrams and color-color diagrams to those of the Large Magellanic Cloud (LMC), finding that the brightest infrared sources in the SMC are also the red supergiants, supergiant B[e] (sgB[e]) stars, luminous blue variables, and Wolf-Rayet stars, with the latter exhibiting less infrared excess, the red supergiants being less dusty and the sgB[e] stars being on average less luminous. Among the objects detected at 24 um are a few very luminous hypergiants, 4 B-type stars with peculiar, flat spectral energy distributions, and all 3 known luminous blue variables. We detect a distinct Be star sequence, displaced to the red, and suggest a novel method of confirming Be star candidates photometrically. We find a higher fraction of Oe and Be stars among O and early-B stars in the SMC, respectively, when compared to the LMC, and that the SMC Be stars occur at higher luminosities. We estimate mass-loss rates for the red supergiants, confirming the correlation with luminosity even at the metallicity of the SMC. Finally, we confirm the new class of stars displaying composite A & F type spectra, the sgB[e] nature of 2dFS1804 and find the F0 supergiant 2dFS3528 to be a candidate luminous blue variable with cold dust.

Reference: Astron.J.140:416-429,2010
Status: Manuscript has been accepted

Weblink: http://adsabs.harvard.edu/abs/2010AJ....140..416B

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Modeling broadband X-ray absorption of massive star winds

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We present a method for computing the net transmission of X-rays emitted by shock-heated plasma distributed throughout a partially optically thick stellar wind from a massive star. We find the transmission by an exact integration of the formal solution, assuming the emitting plasma and absorbing plasma are mixed at a constant mass ratio above some minimum radius, below which there is assumed to be no emission. This model is more realistic than either the slab absorption associated with a corona at the base of the wind or the exospheric approximation that assumes all observed X-rays are emitted without attenuation from above the radius of optical depth unity. Our model is implemented in XSPEC as a pre-calculated table that can be coupled to a user-defined table of the wavelength dependent wind opacity. We provide a default wind opacity model that is more representative of real wind opacities than the commonly used neutral ISM tabulation. Preliminary modeling of textit{Chandra} grating data indicates that the X-ray hardness trend of OB stars with spectral subtype can largely be understood as a wind absorption effect.

Reference: Accepted by ApJ
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1007.0783

Comments: Model available at http://heasarc.gsfc.nasa.gov/docs/xanadu/xspec/models/windprof.html

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The ^{13}Carbon footprint of B[e] supergiants

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We report on the first detection of ^{13}C enhancement in two B[e] supergiants in the Large Magellanic Cloud. Stellar evolution models predict the surface abundance in ^{13}C to strongly increase during main-sequence and post-main sequence evolution of massive stars. However, direct identification of chemically processed material on the surface of B[e] supergiants is hampered by their dense, disk-forming winds, hiding the stars. Recent theoretical computations predict the detectability of enhanced ^{13}C via the molecular emission in ^{13}CO arising in the circumstellar disks of B[e] supergiants. To test this potential method and to unambiguously identify a post-main sequence B[e]SG by its ^{13}CO emission, we have obtained high-quality K-band spectra of two known B[e] supergiants in the Large Magellanic Cloud, using the Very Large Telescope's Spectrograph for INtegral Field Observation in the Near-Infrared (VLT/SINFONI). Both stars clearly show the ^{13}CO band emission, whose strength implies a strong enhancement of ^{13}C, in agreement with theoretical predictions. This first ever direct confirmation of the evolved nature of B[e] supergiants thus paves the way to the first identification of a Galactic B[e] supergiant.

Reference: To be published in MNRAS Letters
Status: Manuscript has been accepted

Weblink:

Comments: 5 pages, 4 figures, 2 tables

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Constraints on rotational mixing from surface evolution of light elements in massive stars

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Context. Light elements and nitrogen surface abundances together can constrain the mixing efficiencies in massive stars on the main sequence, because moderate mixing at the surface leads to a depletion of light elements but only later to an enrichment in nitrogen.
Aims. We want to test the rotational mixing prescriptions included in the Geneva stellar evolution code (GENEC) by following the evolution of surface abundances of light isotopes in massive stars.
Methods. The GENEC is a 1D code containing sophisticated prescriptions for rotational mixing. We implemented an extended reaction network into this code including the light elements Li, Be and B, which allowed us to perform calculations testing the rotation induced mixing.
Results. We followed 9, 12 and 15 solar mass models with rotation from the zero age main sequence up to the end of He burning. The calculations show the expected behaviour with faster depletion of light isotopes for faster rotating stars and more massive stars.
Conclusions. We find that the mixing prescriptions used in the present rotating models for massive single stars can account for most of the observations. However the uncertainties are quite large making it hard to draw a firm conclusion on the mixing scenario.

Reference: A&A
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1007.1779

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Time, spatial, and spectral resolution of the Halpha line-formation region of Deneb and Rigel with the VEGA/CHARA interferometer

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BA-type supergiants are amongst the most optically-bright stars. They are observable in extragalactic environments, hence potential accurate distance indicators. Emission activity in the Halpha line of the BA supergiants Rigel (B8Ia) and Deneb (A2Ia) is indicative of presence of localized time-dependent mass ejections. Here, we employ optical interferometry to study the Halpha line-formation region in these stellar environments. High spatial- (0.001 arcsec) and spectral- (R=30 000) resolution observations of Halpha were obtained with the visible recombiner VEGA installed on the CHARA interferometer, using the S1S2 array-baseline (34m). Six independent observations were done on Deneb over the years 2008 and 2009, and two on Rigel in 2009. We analyze this dataset with the 1D non-LTE radiative-transfer code CMFGEN, and assess the impact of the wind on the visible and near-IR interferometric signatures, using both Balmer-line and continuum photons. We observe a visibility decrease in Halpha for both Rigel and Deneb, suggesting that the line-formation region is extended (1.5-1.75 R*). We observe a significant visibility decrease for Deneb in the SiII6371 line. We witness time variations in the differential phase for Deneb, implying an inhomogeneous and unsteady circumstellar environment, while no such variability is seen in differential visibilities. Radiative-transfer modeling of Deneb, with allowance for stellar-wind mass loss, accounts fairly well for the observed decrease in the Halpha visibility. Based on the observed differential visibilities, we estimate that the mass-loss rate of Deneb has changed by less than 5%.

Reference: Astronomy and Astrophysics
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1007.2095

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The R136 star cluster hosts several stars whose individual masses greatly exceed the accepted 150 Msun stellar mass limit

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Spectroscopic analyses of H-rich WN5-6 stars within the young star clusters NGC 3603 and R136 are presented, using archival HST & VLT spectroscopy, & high spatial resolution near-IR photometry. We derive high T* for the WN stars in NGC 3603 (T*~42+/-2 kK) & R136 (T*~53+/-3 kK) plus clumping-corrected dM/dt ~ 2-5x10^-5 Msun/yr which closely agree with theoretical predictions. These stars make a disproportionate contribution to the global budget of their host clusters. R136a1 alone supplies ~7% of N(LyC) of the entire 30 Dor region. Comparisons with stellar models calculated for the main- sequence evolution of 85-500 Msun suggest ages of ~1.5 Myr & M_init in the range 105 - 170 Msun for 3 systems in NGC 3603, plus 165-320 Msun for 4 stars in R136. Our high stellar masses are supported by dynamical mass determinations for the components of NGC 3603 A1. We consider the predicted L_X of the R136 stars if they were close, colliding wind binaries. R136c is consistent with a colliding wind binary system. However, short period, colliding wind systems are excluded for R136a WN stars if mass ratios are of order unity. Widely separated systems would have been expected to harden owing to early dynamical encounters with other massive stars in such a dense environment. From simulated star clusters, whose constituents are randomly sampled from the Kroupa IMF, both clusters are consistent with a tentative upper mass limit of ~300 Msun. The Arches cluster is either too old, exhibits a deficiency of very massive stars, or more likely stellar masses have been underestimated - M_init for the most luminous stars in the Arches cluster approach 200 Msun according to contemporary stellar & photometric results. The potential for stars greatly exceeding 150 Msun within metal-poor galaxies suggests that such pair-instability SNe could occur within the local universe, as has been claimed for SN 2007bi (abridged).

Reference: MNRAS in press, 20 pages.
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1007.3284

Comments: Version with higher resolution figures is available from
http://pacrowther.staff.shef.ac.uk/R136.pdf
See also http://www.eso.org/public/news/eso1030/ from Wed 21 from noon (CEST)

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Chandra HETG Observations of the Colliding Stellar Wind System WR 147

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We present an extended analysis of deep Chandra HETG observations of the WR+OB binary system WR 147 that was resolved into a double X-ray source (Zhekov & Park, 2010, ApJ, 709, L119). Our analysis of the profiles of strong emission lines shows that their centroids are blue-shifted in the spectrum of the northern X-ray source. We find no suppressed forbidden line in the He-like triplets which indicates that the X-ray emitting region is not located near enough to the stars in the binary system to be significantly affected by their UV radiation. The most likely physical picture that emerges from the entire set of HETG data suggests that the northern X-ray source can be associated with the colliding stellar wind region in the wide WR+OB binary system, while the X-rays of its southern counterpart, the WN8 star, are result from stellar wind shocking onto a close companion (a hypothesized third star in the system).

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Status: Manuscript has been accepted

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A Multi-Phase Suzaku Study of X-rays from tau Sco

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We obtained relatively high signal-to-noise X-ray spectral data of the early massive star tau~Sco (B0.2V) with the {it Suzaku} XIS instrument. This source displays several unusual features that motivated our study: (a) redshifted absorption in UV P~Cygni lines to approximately $+250$ km~s^{-1} suggestive of infalling gas, (b) unusually hard X-ray emission requiring hot plasma at temperatures in excess of 10~MK whereas most massive stars show relatively soft X-rays at a few~MK, and (c) a complex photospheric magnetic field of open and closed field lines. In an attempt to understand the hard component better, X-ray data were obtained at six roughly equally spaced phases within the same epoch of tau~Sco's 41~day rotation period. The XIS instrument has three operable detectors: XIS1 is back illuminated with sensitivity down to 0.2~keV; XIS0 and XIS2 are front illuminated with sensivitity only down to 0.4~keV and have overall less effective area than XIS1. The XIS0 and XIS3 detectors show relatively little variability. In contrast, there is a $approx 4sigma$ detection of a $approx 4%$ drop in the count rate of the XIS1 detector at one rotational phase. In addition, all three detectors show a $approx 3% $ increase in count rate at the same phase. The most optimistic prediction of X-ray variability allows for a 40% change in the count rate, particularly near phases where we have pointings. Observed modulations in the X-ray light curve on the rotation cycle is an order of magnitude smaller than this, which places new stringent constraints on future modeling of this interesting magnetic massive star.

Reference: to appear in ApJ
Status: Manuscript has been accepted

Weblink: astroph/1008.1552

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Probing local density inhomogeneities in the circumstellar disk of a Be star using the new spectro-astrometry mode at the Keck interferometer

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We report on the successful science verification phase of a new observing mode at the Keck interferometer, which provides a line-spread function width and sampling of 150 km/s at K′-band, at a current limiting magnitude of K′ = 7 mag with spatial resolution of lambda / 2B = 2.7 mas and a measured differential phase stability of unprecedented precision (3 mrad at K = 5mag, which represents 3 μas on sky or a centroiding precision of 10^−3). The scientific potential of this mode is demonstrated by the presented observations of the circumstellar disk of the evolved Be-star 48 Lib. In addition to indirect methods such as multi-wavelength spectroscopy and polaritmetry, the here described spectro-interferometric astrometry provides a new tool to directly constrain the radial density structure in the disk. We resolve for the first time several Pfund emission lines, in addition to Br Gam, in a single interferometric spectrum, and with adequate spatial and spectral resolution and precision to analyze the radial disk structure in 48 Lib. The data suggest that the continuum and Pf-emission originates in significantly more compact regions, inside of the Br Gam emission zone. Thus, spectro-interferometric astrometry opens the opportunity to directly connect the different observed line profiles of Br Gam and Pfund in the total and correlated flux to different disk radii. The gravitational potential of a rotationally flattened Be star is expected to induce a one-armed density perturbation in the circumstellar disk. Such a slowly rotating disk oscillation has been used to explain the well known periodic V/R spectral profile variability in these stars, as well as the observed V/R cycle phase shifts between different disk emission lines. The differential line properties and linear constraints set by our data are consistent with theoretical models and lend direct support to the existence of a radius-dependent disk density perturbation. The data

also shows decreasing gas rotation velocities at increasing stello-centric radii as expected for Keplerian disk rotation, assumed by those models.

Reference: ApJ in press
Status: Manuscript has been accepted

Weblink: http://de.arxiv.org/abs/1008.1727

Comments: 28 pages, 4 figures, Accepted for publication by ApJ

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Circumventing the radiation pressure barrier in the formation of massive stars via disk accretion

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We present radiation hydrodynamics simulations of the collapse of massive pre-stellar cores. We treat frequency dependent radiative feedback from stellar evolution and accretion luminosity at a numerical resolution down to 1.27 AU.
In the 2D approximation of axially symmetric simulations, it is possible for the first time to simulate the whole accretion phase (up to the end of the accretion disk epoch) for the forming massive star and to perform a broad scan of the parameter space. Our simulation series show evidently the necessity to incorporate the dust sublimation front to preserve the high shielding property of massive accretion disks. While confirming the upper mass limit of spherically symmetric accretion, our disk accretion models show a persistent high anisotropy of the corresponding thermal radiation field. This yields to the growth of the highest-mass stars ever formed in multi-dimensional radiation hydrodynamics simulations, far beyond the upper mass limit of spherical accretion. Non-axially symmetric effects are not necessary to sustain accretion. The radiation pressure launches a stable bipolar outflow, which grows in angle with time as presumed from observations.
For an initial mass of the pre-stellar host core of 60, 120, 240, and 480 Msun the masses of the final stars formed in our simulations add up to 28.2, 56.5, 92.6, and at least 137.2 Msun respectively.

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Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1008.4516

Comments:

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Abstracts of 1 submitted papers

Measured Metallicities at the Sites of Stripped Core-Collapse Supernovae

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Metallicity is expected to influence not only the lives of massive stars but also the outcome of their deaths as supernovae (SNe) and as gamma-ray bursts (GRBs). However, there are surprisingly few direct measurements of the local metallicities of different flavors of core-collapse SNe. Here we present the largest existing set of host-galaxy spectra with H II region emission lines at the sites of 34 stripped-envelope core-collapse SNe. We derive local oxygen abundances in a robust manner in order to constrain the SN Ib/c progenitor population. We obtain spectra at the SN sites, include SNe from targeted and untargeted surveys, and perform the abundance determinatinos using three different oxygen-abundance calibrations. The sites of SNe Ic (the demise of the most heavily stripped stars having lost both the H and He layers) are systematically more metal rich than those of SNe Ib (arising from stars that retained their He layer) in all calibrations. A Kolmogorov-Smirnov-test yields a very low probability of 0.1% that SN Ib and SN Ic environment abundances, which are different on average by 0.2 dex (in the Pettini & Pagel scale), are drawn from the same parent population. Broad-lined SNe Ic (without GRBs) occur at metallicities between those of SNe Ib and SNe Ic. Lastly, we find that the host-galaxy central oxygen abundance, widely inferred from the host-galaxy luminosity, is not a good indicator of the local SN metallicity; hence, large-scale SN surveys need to obtain local abundance measurements in order to quantify the impact of metallicity on stellar death.

Reference: Modjaz et al. (2010), ApJL submitted
Status: Manuscript has been submitted

Weblink: http://xxx.lanl.gov/abs/1007.0661

Comments:

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Abstracts of 1 conference proceedings

The Slope of the Upper End of the IMF and the Upper Mass Limit: An Observer's Perspective

Philip Massey

Lowell Observatory

There are various ways of measuring the slope of the upper end of the IMF. Arguably the most direct of

these is to place stars on the H-R diagram and compare their positions with stellar evolutionary models. Even so, the masses one infers from this depend upon the exact methodology used. I briefly discuss some of the caveats and go through a brief error analysis. I conclude that the current data suggest that the IMF slopes are the same to within the errors. Similarly the determination of the upper mass "limit" is dependent upon how well one can determine the masses of the most massive stars within a cluster. The recent finding by Crowther et al (2010) invalidates the claim that there is a 150Mo upper limit to the IMF, but this is really not surprising given the weakness of the previous evidence.

Reference: To appear in "UP: Have Observations Revealed a Variable Upper End of the Initial Mass Function"
Status: Conference proceedings

Weblink: http://www.lowell.edu/users/massey/UP2010.pdf

Comments:

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JOBS

Post-doctoral Position at the University of São Paulo, Brazil

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Applications are invited for a Fapesp-funded post-doctoral scholarship at the Astronomy Department of University of São Paulo to work on models of circumstellar disks and outflows, with emphasis on Be stars, in the context of an integrated observational and theoretical effort in collaboration with Drs. Thomas Rivinius, Stanislav Stefl and Dietrich Baade (ESO) and Dr. Atsuo Okazaki (Hokkai-Gakuen University, Japan).

The University of São Paulo is one of the most important research institutes in Latin America. The Astronomy Department has a consolidated research tradition in many astrophysical fields and currently has 38 professors, about 50 PhD students, 30 MS students and 25 post-docs from many different countries.

Fapesp post-doctoral scholarship is of about US$ 2,800 per month, free of taxes, plus a research grant of about US$ 5,000 per year. Travel and moving expenses are also included (one month extra salary plus plane tickets). The position is funded for up to two years. A PhD degree and relevant research experience are required.

Because the post-doctoral scholarship of Fapesp are awarded to the research project, the application process will have two phases:

* Phase 1 (Deadline 07/31/2010)
Selection of one candidate among the applicants based on their CV, publication record, and research expertise.

* Phase 2 (Deadline 08/30/2010)
Submission of a research project to Fapesp, written by both the successful candidate of phase 1 and the supervisor (Alex C. Carciofi).

Applicants for phase 1 are invited to contact Alex C. Carciofi by email (carciofi@usp.br) before July 31st, 2010. The requirements for phase 1 application are: CV, publication list, and a statement of research interests.

Attention/Comments:

Weblink:

Email: carciofi@usp.br

Deadline:

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