ISSN 1783-3426

THE MASSIVE STAR NEWSLETTER

formely known as the hot star newsletter

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No. 124 2011 July-August

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PAPERS

Abstracts of 12 accepted papers

The two components of the evolved massive binary LZ Cep. Testing the effects of binarity on stellar evolution

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Aims. We present an in-depth study of the two components of the binary system LZCep in order to constrain the effects of binarity on the evolution of massive stars.
Methods. We use a set of high-resolution, high signal–to-noise ratio optical spectra obtained over the orbital period of the system to perform a spectroscopic disentangling and derive an orbital solution. We subsequently determine the stellar properties of each component through an analysis with the CMFGEN atmosphere code. Finally, with the derived stellar parameters, we model the Hipparcos photometric light curve using the program NIGHTFALL to obtain the inclination and the real stellar masses.
Results. LZCep is a O9III+ON9.7V binary. It is as a semi-detached system in which either the primary or the secondary star almost fills up its Roche lobe. The dynamical masses are about 16.0 M⊙ (primary) and 6.5 M⊙ (secondary). The latter is lower than the typical mass of late–type O stars. The secondary component is chemically more evolved than the primary (which barely shows any sign of CNO processing), with strong helium and nitrogen enhancements as well as carbon and oxygen depletions. These properties (surface abundances and mass) are typical of Wolf-Rayet stars, although the spectral type is ON9.7V. The luminosity of the secondary is consistent with that of core He–burning objects. The preferred, tentative evolutionary scenario to explain the observed properties involves mass transfer from the secondary – which was initially more massive– towards the primary. The secondary is now almost a core He–burning object, probably with only a thin envelope of H–rich and CNO processed material. A very inefficient mass transfer is necessary to explain the chemical appearance of the primary. Alternative scenarios are discussed but they suffer from more uncertainties.

Reference: A&A, in press
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1106.6162

Comments: 11 pages, 10 figures, 3 tables

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Variability in the CoRoT photometry of three hot O-type stars. HD 46223, HD 46150 and HD 46966.

R. Blomme (1), L. Mahy (2), C. Catala (3), J. Cuypers (1), E. Gosset (2), M. Godart (2), J. Montalban (2), P. Ventura (4), G. Rauw (2), T. Morel (2), P. Degroote (5), C. Aerts (5,6), A. Noels (2), E. Michel (3), F. Baudin (7), A. Baglin (3), M. Auvergne (3), R. Samadi (3)

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The detection of pulsational frequencies in stellar photometry is required as input for asteroseismological modelling. The second short run (SRa02) of the CoRoT mission has provided photometric data of unprecedented quality and time-coverage for a number of O-type stars.
We analyse the CoRoT data corresponding to three hot O-type stars, describing the properties of their light curves and we search for pulsational frequencies, which we then compare to theoretical model predictions.
We determine the amplitude spectrum of the data, using the Lomb-Scargle and a multifrequency HMM-like technique. Frequencies are extracted by prewhitening, and their significance is evaluated under the assumption that the light curve is dominated by red noise. We search for harmonics, linear combinations and regular spacings among these frequencies. We use simulations with the same time sampling as the data as a powerful tool to judge the significance of our results. From the theoretical point of view, we use the MAD non-adiabatic pulsation code to determine the expected frequencies of excited modes.
A substantial number of frequencies is listed, but none can be convincingly identified as being connected to pulsations. The amplitude spectrum is dominated by red noise. Theoretical modelling shows that all three O-type stars can have excited modes but the relation between the theoretical frequencies and the observed spectrum is not obvious.
The dominant red noise component in the hot O-type stars studied here clearly points to a different origin than the pulsations seen in cooler O stars. The physical cause of this red noise is unclear, but we speculate on the possibility of sub-surface convection, granulation, or stellar wind inhomogeneities being responsible.

Reference: A&A, in press
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1107.0267

Comments: 13 pages, 8 figures. Tables 2, 3 and 4 available on ftp://omaftp.oma.be/dist/astro/Blomme.R/CoRoT/

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Confirmation of the magnetic oblique rotator model for the Of?p star HD 191612

G.A. Wade, I.D. Howarth, R.H.D. Townsend, J.H. Grunhut, M. Shultz, J.-C. Bouret, A. Fullerton, W. Marcolino, F. Martins, Y. Naze, A. ud Doula, N.R. Walborn, J.-F. Donati, and the MiMeS Collaboration

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This paper reports high-precision Stokes V spectra of HD 191612 acquired using the ESPaDOnS spectropolarimeter at the Canada-France-Hawaii Telescope, in the context of the Magnetism in Massive stars (MiMeS) Project. Using measurements of the equivalent width of the Hα line and radial velocities of various metallic lines, we have updated both the spectroscopic and orbital ephemerides of this star. We confirm the presence of a strong magnetic field in the photosphere of HD 191612, and detect its variability. We establish that the longitudinal field varies in a manner consistent with the spectroscopic period of 537.6 d, in an approximately sinusoidal fashion. The phases of minimum and maximum longitudinal field are respectively coincident with the phases of maximum and minimum Hα equivalent width and Hp magnitude. This demonstrates a firm connection between the magnetic field and the processes responsible for the line and continuum variability. Interpreting the variation of the longitudinal magnetic field within the context of the dipole oblique rotator model, and adopting an inclination $i = 30^\circ$ obtained assuming alignment of the orbital and rotational angular momenta, we obtain a best-fit surface magnetic field model with obliquity $\beta = 67 \pm 5^\circ$ and polar strength $B_d = 2450 \pm 400$ G . The inferred magnetic field strength implies an equatorial wind magnetic confinement parameter $\eta_* \simeq 50$, supporting a picture in which the Hα emission and photometric variability have their origin in an oblique, rigidly rotating magnetospheric structure resulting from a magnetically channeled wind. This interpretation is supported by our successful Monte Carlo radiative transfer modeling of the photometric variation, which assumes the enhanced plasma densities in the magnetic equatorial plane above the star implied by such a picture, according to a geometry that is consistent with that derived from the magnetic field. Predictions of the continuum linear polarisation resulting from Thompson scattering from the magnetospheric material indicate that the Stokes Q and U variations are highly sensitive to the magnetospheric geometry, and that expected amplitudes are in the range of current instrumentation.

Reference: MNRAS, accepted and in press
Status: Manuscript has been accepted

Weblink: http://arxiv.org/pdf/1106.3008v1

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The Eddington factor as the key to understand the winds of the most massive stars. Evidence for a Gamma-dependence of Wolf-Rayet type mass loss

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The most massive stars are thought to be hydrogen-rich Wolf-Rayet stars of late spectral subtype (WNh stars). In previous theoretical studies the enhanced mass loss of these stars has been attributed to their proximity to the Eddington limit. Here we investigate observed trends in the mass-loss properties of such young, very massive stars. We derive theoretical mass-luminosity relations for very massive stars, based on a large grid of stellar structure models. Using these relations, we estimate Eddington factors for a sample of stars, under different assumptions of their evolutionary status. We evaluate the resulting mass-loss relations, and compare them with theoretical predictions. We find observational evidence that the mass loss in the WR regime is dominated by the Eddington parameter Gamma_e, which has important consequences for the way we understand Wolf-Rayet stars and their mass loss. In addition, we derive wind masses that support the picture that the WNh stars in young stellar clusters are very massive, hydrogen-burning stars. Our findings suggest that the proximity to the Eddington limit is the physical reason for the onset of Wolf-Rayet type mass loss. This means that, e.g. in stellar evolution models, the Wolf-Rayet stage should be identified by large Eddington parameters, instead of a helium-enriched surface composition. The latter is most likely only a consequence of strong mass loss, in combination with internal mixing. For very massive stars, the enhanced Gamma-dependent mass loss is responsible for the formation of late WNh subtypes with high hydrogen surface abundances, partly close to solar. Because mass loss dominates the evolution of very massive stars, we expect a strong impact of this effect on their end products, in particular on the potential formation of black holes, and Gamma-Ray Bursts, as well as the observed upper mass limit of stars.

Reference: A&A
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1106.5361

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The bi-stability jump as the origin for multiple P-Cygni absorption components in Luminous Blue Variables

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Luminous Blue Variables (LBVs) oftentimes show double-troughed absorption in their strong Halpha lines, which are as yet not understood. Intriguingly, the feature has also been seen in the interacting supernova SN 2005gj, which was for this reason suggested to have an LBV progenitor. Our aims are to understand the double-troughed absorption feature in LBVs and investigate whether this phenomenon is related to wind variability. To this purpose, we perform time-dependent radiative transfer modeling using CMFGEN. We find that abrupt changes in the wind-terminal velocity - as expected from the bi-stability jump - are required to explain the double-troughed absorption profiles in LBVs. This strengthens scenarios that discuss the link between LBVs and SNe utilizing the progenitor's wind variability resulting from the bi-stability jump. We also discuss why the presence of double-troughed P-Cygni components may become an efficient tool to detect extra-galactic LBVs and how to analyze their mass-loss history on the basis of just one single epoch of spectral observations.

Reference: A&A 531, 10
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1106.3007

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The strong magnetic field of the large-amplitude $beta$,Cephei pulsator V1449,Aql

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Only for very few $beta$~Cephei stars has the behaviour of the magnetic field
been studied over the rotation cycle. During the past two years we have obtained
multi-epoch polarimetric spectra of the $beta$~Cephei star V1449,Aql with
SOFIN at the Nordic Optical Telescope to search for a rotation period and to

constrain the geometry of the magnetic field.

The mean longitudinal magnetic field is measured at 13 different epochs. The new measurements, together with the previous FORS,1 measurements, have been used for the frequency analysis and the characterization of the magnetic field.

V1449,Aql so far possesses the strongest longitudinal magnetic field of up to 700,G among the $beta$,Cephei stars. The resulting periodogram displays three dominant peaks with the highest peak at $f=0.0720$,d^{-1} corresponding to a period $P=13fd893$. The magnetic field geometry can likely be described by a centred dipole with a polar magnetic field strength $B_{rm d}$ around 3,kG and an inclination angle $beta$ of the magnetic axis to the rotation axis of 76pm4^{circ}. As of today, the strongest longitudinal magnetic fields are detected in the $beta$,Cephei stars V1449,Aql and xi^1,CMa with large radial velocity amplitudes. Their peak-to-peak amplitudes reach sim90,km,s^{-1} and sim33,km,s^{-1}, respectively. Concluding, we briefly discuss the position of the currently known eight magnetic $beta$,Cephei and candidate $beta$,Cephei stars in the Hertzsprung-Russell (H-R) diagram.

Reference: A&A 531, L20 (2011)
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1107.0883

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N II 5668-5712, a New Class of Spectral Features in Eta Carinae

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We report on the N II 5668-5712 emission and absorption lines in the spectrum of eta Carinae. Spectral lines of the stellar wind regions can be classified into four physically distinct categories: 1) low-excitation emission such as H I and Fe II, 2) higher excitation He I features, 3) the N II lines discussed in this paper, and 4) He II emission. These categories have different combinations of radial velocity behavior, excitation processes, and dependences on the secondary star. The N II lines are the only known features that originate in “normal” undisturbed zones of the primary wind but depend primarily on the location of the hot secondary star. N II probably excludes some proposed models, such as those where He I lines originate in the secondary star’s wind or in an accretion disk.

Reference: ApJ
Status: Manuscript has been accepted

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Critical Differences and Clues in Eta Car's 2009 Event

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We monitored Eta Carinae with {it HST/} WFPC2 and {it Gemini/} GMOS throughout the 2009 spectroscopic event, which was expected to differ from its predecessor in 2003. Here we report major observed differences between events, and their implications. Some of these results were quite unexpected. (1) The UV brightness minimum was much deeper in 2009. This suggests that physical conditions in the early stages of an event depend on different parameters than the ``normal" inter-event wind. Extra mass ejection from the primary star is one possible cause. (2) The expected ion{He}{2} $lambda$4687 brightness maximum was followed several weeks later by another. We explain why this fact, and the timing of the $lambda$4687 maxima, strongly support a ``shock breakup" hypothesis for X-ray and $lambda$4687 behavior as proposed 5--10 years ago. (3) We observed a polar view of the star via light reflected by dust in the Homunculus nebula. Surprisingly, at that location the variations of emission-line brightness and Doppler velocities closely resembled a direct view of the star; which should not have been true for any phenomena related to the orbit. This result casts very serious doubt on all the proposed velocity interpretations that depend on the secondary star's orbital motion. (4) Latitude-dependent variations of ion{H}{1}, ion{He}{1} and ion{Fe}{2} features reveal aspects of wind behavior during the event. In addition, we discuss implications of the observations for several crucial unsolved problems.

Reference: ApJ
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1106.5869

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On the Origin of the Salpeter Slope for the Initial Mass Function

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We suggest that the intrinsic, stellar initial mass function (IMF) follows a power-law slope gamma=2, inherited from hierarchical fragmentation of molecular clouds into clumps and clumps into stars. The well-known, logarithmic Salpeter slope GAMMA=1.35 in clusters is then the aggregate slope for all the star-forming clumps contributing to an individual cluster, and it is steeper than the intrinsic slope within individual clumps because the smallest star-forming clumps contributing to any given cluster are unable to form the highest-mass stars. Our Monte Carlo simulations demonstrate that the Salpeter power-law index is the limiting value obtained for the cluster IMF when the lower-mass limits for allowed stellar masses and star-forming clumps are effectively equal, m_lo = M_lo. This condition indeed is imposed for the high-mass IMF tail by the turn-over at the characteristic value $m_csim 1 rm M_sun. IMF slopes of

GAMMA ~ 2 are obtained if the stellar and clump upper-mass limits are also equal, m_up = M_up ~ 100 M_sun, and so our model explains the observed range of IMF slopes between GAMMA ~ 1 to 2. Flatter slopes of GAMMA = 1 are expected when M_lo > m_up, which is a plausible condition in starbursts, where such slopes are suggested to occur. While this model is a simplistic parameterization of the star-formation process, it seems likely to capture the essential elements that generate the Salpeter tail of the IMF for massive stars. These principles also likely explain the IGIMF effect seen in low-density star-forming environments.

Reference: ApJ Letters, in press
Status: Manuscript has been accepted

Weblink: http://adsabs.harvard.edu/abs/2011arXiv1108.2287O

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Jet formation from massive young stars: Magnetohydrodynamics versus radiation pressure

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Observations indicate that outflows from massive young stars are more collimated during their early evolution compared to later stages.
Our paper investigates various physical processes that impacts the
outflow dynamics, i.e. its acceleration and collimation.
We perform axisymmetric MHD simulations particularly considering the radiation
pressure exerted by the star and the disk.
We have modified the PLUTO code to include radiative forces
in the line-driving approximation.
We launch the outflow from the innermost disk region ($r < 50$,AU)
by magneto-centrifugal acceleration.
In order to disentangle MHD effects from radiative forces, we start the
simulation in pure MHD, and later switch on the radiation force.
We perform a parameter study considering different stellar masses (thus luminosity),
magnetic flux, and line-force strength.
For our reference simulation - assuming a $30msun$ star, we find substantial de-collimation of 35% due to radiation forces.
The opening angle increases from 20^circ to 32^circ for stellar masses from
$20msun$ to $60msun$.
A small change in the line-force parameter $alpha$ from 0.60 to 0.55 changes the opening angle
by $sim 8^circ$.
We find that it is mainly the stellar radiation which affects the jet
dynamics. Unless the disk extends very close to the star, its pressure is too small to have much impact.
Essentially, our parameter runs with different stellar mass can be understood
as a proxy for the time evolution of the star-outflow system.
Thus, we have shown that when the stellar mass (thus luminosity) increases
(with age), the outflows become less collimated.

Reference: Accepted for publication in ApJ

Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1108.4924

Comments:

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L-band spectroscopy of Galactic OB-stars

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Context. Mass-loss, occurring through radiation driven supersonic winds, is a key issue throughout the evolution of massive stars. Two outstanding problems are currently challenging the theory of radiation-driven winds: wind clumping and the weak-wind problem. Aims. We seek to obtain accurate mass-loss rates of OB stars at different evolutionary stages to constrain the impact of both problems in our current understanding of massive star winds. Methods. We perform a multi-wavelength quantitative analysis of a sample of ten Galactic OB-stars by means of the atmospheric code CMFGEN, with special emphasis on the L-band window. A detailed investigation is carried out on the potential of Bralpha and Pfgamma as mass-loss and clumping diagnostics. Results. For objects with dense winds, Bralpha samples the intermediate wind while Pfgamma maps the inner one. In combination with other indicators (UV, Halpha, Brgamma) these lines enable us to constrain the wind clumping structure and to obtain "true" mass-loss rates. For objects with weak winds, Bralpha emerges as a reliable diagnostic tool to constrain the mass-loss rates. The emission component at the line Doppler-core superimposed on the rather shallow Stark absorption wings reacts very sensitively to mass loss already at very low mass-loss values. On the other hand, the line wings display similar sensitivity to mass loss as Halpha, the classical optical mass loss diagnostics. Conclusions. Our investigation reveals the great diagnostic potential of L-band spectroscopy to derive clumping properties and mass-loss rates of hot star winds. We are confident that Bralpha will become the primary diagnostic tool to measure very low mass-loss rates with unprecedented accuracy

Reference: A&A
Status: Manuscript has been accepted

Weblink: http://es.arxiv.org/abs/1108.5752v1

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Further Results from the Galactic O-Star Spectroscopic Survey: Rapidly Rotating Late ON Giants

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With new data from the Galactic O-Star Spectroscopic Survey, we confirm and expand the ONn category of late-O, nitrogen-enriched (N), rapidly rotating (n) giants. In particular, we have discovered two ``clones'' (HD 102 415 and HD 117 490) of one of the most rapidly rotating O stars previously known (HD 191 423, ``Howarth's Star''). We compare the locations of these objects in the theoretical HR Diagram to those of slowly rotating ON dwarfs and supergiants. All ON giants known to date are rapid rotators, whereas no ON dwarf or supergiant is; but all ON stars are small fractions of their respective spectral- type/luminosity-class/rotational subcategories. The ONn giants, displaying both substantial processed material and high rotation at an intermediate evolutionary stage, may provide significant information about the development of those prop- erties. They may have preserved high initial rotational velocities or been spun up by TAMS core contraction; but alternatively and perhaps more likely, they may be products of binary mass transfer. At least some of them are also runaway stars.

Reference: To appear in the November 2011 issue of AJ
Status: Manuscript has been accepted

Weblink:

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MEETINGS

Circumstellar Dynamics at High Resolution

February 27th - March 02nd, 2012

Venue: Foz do Iguaçu, Brazil

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* First Announcement
*
* Workshop
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* Circumstellar Dynamics at High Resolution
*
* Foz do Iguaçu, Brazil, February 27 - March 02, 2012
*
* ESO - Univ. of São Paulo
*
****

This is the first announcement of a conference on "Circumstellar Dynamics at High Resolution" to be held February 27 to March 02, 2012. The venue of the meeting will be in Foz do Iguaçu, Brazil.

The Workshop is sponsored by ESO and the University of São Paulo. More detailed information is available on our web page:

http://www.eso.org/sci/meetings/2012/csdyn.html

or by email to csdyninfo@eso.org.

We encourage you to circulate the announcement among your colleagues.

On behalf of the organizers,
Alex Carciofi
****

*** SCOPE ***
The dynamics of circumstellar (CS) envelopes is an active research frontier that has benefited greatly from the advent of high-resolution observational techniques in the spectral, spatial and temporal domains. The observational discoveries and theoretical results emerging from this field have broad implications for many astrophysical topics, ranging from cosmology (via a better understanding of the progenitors of GRBs, for instance), to star and planet formation (through a better description of CS disk dynamics in which viscosity plays a key role).

The diverse and complex CS environments revealed by these observational techniques are particularly evident near hot high-mass stars, where stellar radiation plays a large if not crucial role in continuously shaping the immediate environment.

High-resolution observations (spatial, spectral, and temporal) have provided important information in several frontline research topics. For example, many hot stars have been shown to be very rapidly rotating, in a regime where geometric deformation and gravity darkening become important. CS structures have not only been resolved spatially, but have been followed over characteristic variation timescales. This dynamical evolution has been modeled for disks and winds: we are now directly observing and measuring the consequence of the physical mechanisms operating within the CS environments. As a result, current observing facilities have allowed the field to progress from a static picture of the CS environment towards understanding its dynamics and concomitant impact on the evolution of the central star.

This workshop aims at bringing together the active community of hot stellar astrophysics, both theoreticians and observers, along the common topic of what can be learned from high resolution observations.

*** PROGRAM ***
Oral sessions during the meeting will be held on:
1) Circumstellar Disks & Outflows: Theory
2) Circumstellar Disks & Outflows: Observations
3) Delta Sco and Be stars as laboratories for CS disk physics
4) Dynamics of Circumstellar Material and tidal interactions in hot binaries
5) Massive star formation out of a dynamic environment
6) Magnetospheres of Hot Stars

*** VENUE ***
The workshop will take place in Foz do Iguaçu, Brazil, close to the magnificent Iguaçu Waterfalls, a network of 275 waterfalls in the Iguaçu River that lies in the border of Brazil and Argentina. The site was designated World Heritage by UNESCO. Tourist attractions include visits to both the Brazilian and Argentinian sides of the Falls, natural parks, and the dam of the Itaipu Hydroeletric Facility. In 1994, the American Society of Civil Engineers elected the Itaipu Dam as one of the seven modern Wonders of the World.

The Meeting will take place in the Rafain Hotel and Convention Centers (http://www.rafainpalace.com.br/v2/home/). Special rates are available for the period of the conference. Hotel costs are 274 BRL (170 USD) for single occupancy and 171 BRL (106 USD) per person for double occupancy. Those rates include full board (breakfast, morning coffebreak, lunch, afternoon coffebreak and dinner).

IMPORTANT NOTE: all participants are encouraged to register in this hotel for two reasons. First, those low rates will only be secured if a minimum of 50 rooms is booked. Second, the hotel is far from the city (10km) and there are no restaurants nearby.

*** PRE-REGISTRATION ***
If you intend to participate in the workshop please fill in the pre-registration form in our web page. This is not a formal registration, and requires no commitment from you. Our goal is to have an idea about the number of participants for organization purposes.

*** PROCEEDINGS ***
We will have online conference proceedings, whether these will be published in print depends on funding decisions made towards the end of 2011 only.

*** FINANCIAL MATTERS ***
The workshop fee will be 200 USD. We will have some limited financial support for students and young researchers. Money will be requested for the Brazilian students that do not have research contingency funds.

*** DEADLINES ***
Requests for financial support must be submitted by Nov. 1st at the latest, together with the abstract of the intended contribution. The deadline for the final registration and abstracts is Dec. 17th.

*** CONTACT ***
- Website: http://www.eso.org/sci/meetings/2012/csdyn.html
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