COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Deriving the Radial-Velocity Variations Induced by Stellar Activity from High-Precision Photometry – Test on HD 189733 with Simultaneous MOST/SOPHIE Data

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Stellar activity induces apparent radial velocity (RV) variations in late-type main-sequence stars that may hamper the detection of low-mass planets and the measurement of their mass. We use simultaneous measurements of the active planet host star HD 189733 with high-precision optical photometry by the MOST satellite and high-resolution spectra by SOPHIE. We apply on this unique dataset a spot model to predict the activity-induced RV variations and compare them with the observed ones. The model is based on the rotational modulation of the stellar flux. A maximum entropy regularization is applied to find a unique and stable solution for the distribution of the active regions versus stellar longitude. The RV variations are synthesized considering the effects on the line profiles of the brightness perturbations due to dark spots and bright faculae and the reduction of the convective blueshifts in the active regions. The synthesized RV time series shows a remarkably good agreement with the observed one although variations on timescales shorter than $4-5$ days cannot be reproduced by our model. Persistent active longitudes are revealed by the spot modelling. They rotate with slightly different periods yielding a minimum relative amplitude of

the differential rotation of $\Delta\Omega/\Omega = 0.23 \pm 0.10$. Moreover, several active regions with an evolution timescale of $2-5$ days and an area of $0.1-0.3$ percent of the stellar disc are detected. The method proves capable of reducing the power of the activity-induced RV variations by a factor from 2 to 10 at the rotation frequency and its harmonics up to the third. Thanks to the high-precision space-borne photometry delivered by CoRoT, Kepler, or later PLATO, it is possible to map the longitudinal distribution of active regions in late-type stars and apply the method presented in this paper to reduce remarkably the impact of stellar activity on their RV jitter allowing us to confirm the detection of low-mass planets or refine the measurement of their mass.

Accepted by A&A

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For preprints via WWW: http://arxiv.org/abs/1107.4864

3D LTE Spectral Line Formation with Scattering in Red Giant Stars

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We investigate the effects of coherent isotropic continuum scattering on the formation of spectral lines in local thermodynamic equilibrium (LTE) using 3D hydrodynamical and 1D hydrostatic model atmospheres of red giant stars. Continuum flux levels, spectral line profiles and curves of growth for different species are compared with calculations that treat scattering as absorption. Photons may escape from deeper, hotter layers through scattering, resulting in significantly higher continuum flux levels beneath a wavelength of 5000 Å. The magnitude of the effect is determined by the importance of scattering opacity with respect to absorption opacity; we observe the largest changes in continuum flux at the shortest wavelengths and lowest metallicities; intergranular lanes of 3D models are more strongly affected than granules. Continuum scattering acts to increase the profile depth of LTE lines: continua gain more brightness than line cores due to their larger thermalization depth in hotter layers. We thus observe the strongest changes in line depth for high-excitation species and ionized species, which contribute significantly to photon thermalization through their absorption opacity near the continuum optical surface. Scattering desaturates the line profiles, leading to larger abundance corrections for stronger lines, which reach -0.5 dex at 3000 Å for Fe II lines in 3D with excitation potential 2 eV at [Fe/H]=-3.0. The corrections are less severe for low-excitation lines, longer wavelengths, and higher metallicity. Velocity fields increase the effects of scattering by separating emission from granules and intergranular lanes in wavelength. 1D calculations exhibit similar scattering abundance corrections for weak lines, but those for strong lines are generally smaller compared to 3D models and depend on the choice of microturbulence.

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Modeling Nearby FGK Population I Stars: A New Form of Estimating Stellar Parameters Using an Optimization Approach

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Context: Modeling a single star with theoretical stellar evolutionary tracks is a nontrivial problem because of a large number of unknowns compared to the number of observations. A current way of estimating stellar age and mass consists of using interpolations in grids of stellar models and/or isochrones, assuming ad hoc values for the mixing length parameter and the metal-to-helium enrichment, which is normally scaled to the solar values.
Aims: We present a new method to model the FGK main-sequence of Population I stars. This method is capable of simultaneously estimating a set of stellar parameters, namely the mass, the age, the helium and metal abundances, the mixing length parameter, and the overshooting.

Methods: The proposed method is based on the application of a global optimization algorithm (PSwarm) to solve an optimization problem that in turn consists of finding the values of the stellar parameters that lead to the best possible fit of the given observations. The evaluation of the fitting objective function requires the use of a stellar evolution simulation code, however.
Results: The methodology is tested using the Sun and five FGK fictitious stars, and is then adapted to 115 stars with a detailed spectroscopic analysis; half of these are planet-hosting stars.
Conclusions: We present and discuss the stellar parameters estimated for each star in the context of previous works.

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Testing a Predictive Theoretical Model for the Mass Loss Rates of Cool Stars

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The basic mechanisms responsible for producing winds from cool, late-type stars are still largely unknown. We take inspiration from recent progress in understanding solar wind acceleration to develop a physically motivated model of the time-steady mass loss rates of cool main-sequence stars and evolved giants. This model follows the energy flux of magnetohydrodynamic turbulence from a subsurface convection zone to its eventual dissipation and escape through open magnetic flux tubes. We show how Alfven waves and turbulence can produce winds in either a hot corona or a cool extended chromosphere, and we specify the conditions that determine whether or not coronal heating occurs. These models do not utilize arbitrary normalization factors, but instead predict the mass loss rate directly from a star's fundamental properties. We take account of stellar magnetic activity by extending standard age-activity-rotation indicators to include the evolution of the filling factor of strong photospheric magnetic fields. We compared the predicted mass loss rates with observed values for 47 stars and found significantly better agreement than was obtained from the popular scaling laws of Reimers, Schroeder, and Cuntz. The algorithm used to compute cool-star mass loss rates is provided as a self-contained and efficient computer code. We anticipate that the results from this kind of model can be incorporated straightforwardly into stellar evolution calculations and population synthesis techniques.

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The Curious Case of the Alpha Persei Corona: a Dwarf in Supergiant's Clothing?

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Alpha Persei (HD 20902: F5 Iab) is a luminous, nonvariable supergiant located at the blue edge of the Cepheid instability strip. It is one of the brightest coronal X-ray sources in the young open cluster bearing its name, yet warm supergiants as a class generally avoid conspicuous high-energy activity. The Cosmic Origins Spectrograph on *Hubble Space Telescope,* recently has uncovered additional oddities. The 1290–1430 Å far-ultraviolet spectrum of α Per is dominated by photospheric continuum emission, with numerous superposed absorption features, mainly stellar. However, the normal proxies of coronal activity, such as the Si IV 1400 Å doublet ($T \sim 8 \times 10^4$ K), are very weak, as are the chromospheric C II 1335 Å multiplet ($T \sim 3 \times 10^4$ K) and O I 1305 Å triplet. In fact, the Si IV features of α Per not only are narrower than those of later, G-type supergiants of similar $L_{\mathrm{X}}/L_{\mathrm{bol}}$, but also are fainter (in $L_{\mathrm{Si\ IV}}/L_{\mathrm{bol}}$) by two orders of magnitude. Further, a reanalysis of the *ROSAT* pointing on α Per finds the X-ray centroid offset from the stellar position by $9''$, at a moderate level of significance. The FUV and X-ray discrepancies raise the possibility that the coronal source might be unrelated to the supergiant, perhaps an accidentally close dwarf cluster member; heretofore unrecognized in the optical, lost in the glare of the bright star.

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Is There a Non-monotonic Relation Between Photospheric Brightness and Magnetic Field Strength in Solar Plage Regions?

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Context. The relationship between the brightness and field strength of small-scale solar magnetic features is an important factor for solar irradiance variations and a constraint for simulations of solar magneto-convection. Aims: We wish to clarify the origin of the apparent discrepancy between observational results and radiative MHD simulations. Methods: Maps of (bolometric) brightness and magnetic field strength from the simulation of a plage region were convolved and rebinned to mimic observations obtained with telescopes with finite aperture. Results: Image smearing changes the monotonic relation between brightness and field strength obtained at the original resolution of the simulation into a profile with a maximum at intermediate field strength, which is in qualitative agreement with the observations. This result is mainly due to the smearing of strong magnetic fields at the bright edges of magnetic structures into the weakly magnetized adjacent areas. Conclusions: Observational and simulation results are qualitatively consistent with each other if the finite spatial resolution of the observations is taken into account.

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Decay of a Simulated Mixed-polarity Magnetic Field in the Solar Surface Layers

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Magnetic flux is continuously being removed and replenished on the solar surface. To understand the removal process we carried out 3D radiative MHD simulations of the evolution of patches of photospheric magnetic field with equal amounts of positive and negative flux. We find that the flux is removed at a rate corresponding to an effective turbulent diffusivity, eff, of 100-340 km2 s-1, depending on the boundary conditions. For average unsigned flux densities above about 70 Gauss, the percentage of surface magnetic energy coming from different field strengths is almost invariant. The overall process is then one where magnetic elements are advected by the horizontal granular motions and occasionally come into contact with opposite-polarity elements. These reconnect above the photosphere on a comparatively short time scale after which the U loops produced rapidly escape through the upper surface while the downward retraction of inverse-U loops is significantly slower, because of the higher inertia and lower plasma beta in the deeper layers.

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Vortices in Simulations of Solar Surface Convection

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We report on the occurrence of small-scale vortices in simulations of the convective solar surface. Using an eigenanalysis of the velocity gradient tensor, we find the subset of high vorticity regions in which the plasma is swirling. The swirling regions form an unsteady, tangled network of filaments in the turbulent downflow lanes. Near-surface vertical vortices are underdense and cause a local depression of the optical surface. They are potentially observable as bright points in the dark intergranular lanes. Vortex features typically exist for a few minutes, during which they are moved and twisted by the motion of the ambient plasma. The bigger vortices found in the simulations are possibly (cont. →)

but not necessarily, related to observations of granular-scale spiraling pathlines in “cork animations” or feature tracking.

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JOB OPENING

Postdoctoral Position
Brown Dwarf Observations
Stony Brook University (N.Y.)

Stony Brook University invites applications for a Postdoctoral Associate position with Prof. Stanimir Metchev in the fields of low-mass stars, substellar objects, or planetary atmospheres. The successful applicant will be expected to lead aspects of a recently approved Exploration Science program with the Spitzer Space Telescope on the atmospheric properties of brown dwarfs. The candidate will also be expected to actively pursue ground-based observations in support of the Spitzer program. Depending on interest, additional opportunities for collaboration with Metchev's group exist in the fields of exoplanets, planet-forming disks, or the population and evolution of substellar objects.

Stony Brook has a 6% share of the Palomar 5 meter telescope: presently the only telescope with an operational extreme adaptive optics system for imaging extrasolar planets. Stony Brook also has access to the Small and Moderate Aperture Research Telescope System (SMARTS) 1-meter class telescopes in Chile.

Candidates must have a doctoral degree or foreign equivalent in Astronomy or a related field. Background in imaging, precision photometry, or spectroscopic data analysis is highly desired. The start date is flexible, but preferably no later than December 1, 2011.

Please provide a curriculum vitae, a brief statement of research experience and interests, and three letters of recommendation online at:

www.stonybrook.edu/jobs (Category K, Ref. #WC-R-6909-11-08-S)

(electronic submission in one PDF document is highly preferred). The position is open until filled; however, for full consideration, complete applications should be received by October 1, 2011. For further information, please contact Prof. Stanimir Metchev at bdpostdoc@astro.sunysb.edu.

Abstract Guidelines

Abstracts for *COOLNEWS* are solicited for papers that have been recently accepted by or submitted to refereed journals, and for recent Ph.D. theses. Abstracts for conference proceedings articles are *not* posted in *COOLNEWS*. The subject matter should pertain directly to cool stars (spectral types F,G,K,M or L), substellar objects, or the sun. Both theoretical and observational abstracts are appropriate.

Abstracts dealing with cool pre-main-sequence (PMS) stars will generally not be included in *COOLNEWS*, since they are already covered by the *Star Formation Newsletter*. Exceptions to this rule will be considered if the subject matter is truly cross-disciplinary. If you wish to submit a cross-disciplinary abstract on PMS stars, then first submit it to the *Star Formation Newsletter*. After doing so, submit the abstract to *COOLNEWS* accompanied by a short e-mail stating that it has already been submitted to the *Star Formation Newsletter*, and summarizing why it will be of interest to the cool star/solar community at large.

A monthly call for abstracts will be issued and abstracts received by the last day of the month will usually appear in the following month's newsletter. Announcements of general interest to the cool star and solar communities may also be submitted for posting in the newsletter. These might include (but are not restricted to) the following: (i) *Job Openings* directed toward cool star or solar researchers, (ii) announcements of *Upcoming Meetings*, (iii) announcements of *Upcoming Observing Campaigns* for which participation is solicited from the community at large, (iv) reviews of *New Books*, and (v) *General Announcements* that provide or request research-related information. Please send all correspondence to the editor at coolnews@jila.colorado.edu. Abstract templates and back issues can be obtained from the COOLNEWS Web-page at

`http://casa.colorado.edu/~skinners/coolnews.html` .

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