// COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 121 — March 2006 Editor: Steve Skinner (coolnews@jila.colorado.edu)

TABLE OF CONTENTS

Stellar Abstracts

New Precision Orbits of Bright Double-Lined Spectroscopic Binaries. I: RR Lyncis, 12 Bootis, and HR 6169

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Radial velocities from the 2.1 m telescope at McDonald Observatory supplemented with radial velocities from the coudé feed telescope at KPNO provide new precise orbits for the double-lined spectroscopic binaries RR Lyn (A3/A8/A6), 12 Boo (F8IV), and HR 6169 (A2V). We derive orbital dimensions ($a_1 \sin i$ and $a_2 \sin i$) and minimum masses ($m_1 \sin^3 i$ and $m_2 \sin^3 i$) with accuracies of 0.06 to 0.9 %. The three systems, which have V magnitudes of 5.54, 4.83, and 6.42, respectively, are all sufficiently bright that they are easily within the grasp of modern optical interferometers and so afford the prospect, when our spectroscopic observations are complemented by interferometric observations, of fully-determined orbits, precise masses, and distances. In the case of RR Lyn, which is also a detached eclipsing binary with a well-determined orbital inclination ($i = 87.45\,\mathrm{deg} \pm 0.11\,\mathrm{deg}$; Khaliullin et al. 2001), we are able to determine the semimajor axis of the relative orbit, $a = 29.32 \pm 0.04\,\mathrm{R}_{\odot}$, primary and secondary radii of $2.57 \pm 0.02\,\mathrm{R}_{\odot}$ and $1.59 \pm 0.03\,\mathrm{R}_{\odot}$, respectively; and primary and secondary masses of $1.927 \pm 0.008\,\mathrm{M}_{\odot}$ and $1.507 \pm 0.004\,\mathrm{M}_{\odot}$, respectively. Comparison of our new systemic velocity determination, $\gamma = -12.03 \pm 0.04$ km s^{-1}, with the earlier one of Kondo (1976), $\gamma = -11.61 \pm 0.30$ km s^{-1}, shows no evidence of any change in the systemic velocity in the 40 years separating the two measurements, a null result that neither confirms nor contradicts the presence of the low-mass third component proposed by Kaliullin & Khaliullina (2002). Our spectroscopic orbit of 12 Boo is more precise that that of Boden et al. (2005) but confirms their results about this system. Our analysis of HR 6169 has produced a major improvement in its orbital elements. The minimum masses of the primary and secondary are 2.20 ± 0.01 M$_{\odot}$ and 1.64 ± 0.02 M$_{\odot}$, respectively. Although all three systems have eccentric orbits, the six components of the systems are either pseudosynchronously rotating or very nearly so.

Accepted by AJ

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Analysis and Modeling of High Temporal Resolution Spectroscopic Observations of Flares on AD Leo

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We report the results of a high temporal resolution spectroscopic monitoring of the flare star AD Leo. During 4 nights, more than 600 spectra were taken in the optical range using the Isaac Newton Telescope (INT) and the Intermediate Dispersion Spectrograph (IDS). We have observed a large number of short and weak flares occurring very frequently (flare activity > 0.71 hours^{-1}). This is in favour of the very important role that flares can play in stellar coronal heating. The detected flares are non white-light flares and, though most of solar flares belong to this kind, very few such events had been previously observed on stars. The behaviour of different chromospheric lines (Balmer series from Hα to H$_{11}$, Ca II H & K, Na I D$_1$ & D$_2$, He I 4026 Å and He I D$_3$) has been studied in detail for a total of 14 flares. We have also estimated the physical parameters of the flaring plasma by using a procedure which assumes a simplified slab model of flares. All the obtained physical parameters are consistent with previously derived values for stellar flares, and the areas – less than 2.3 % of the stellar surface – are comparable with the size inferred for other solar and stellar flares. Finally, we have studied the relationships between the physical parameters and the area, duration, maximum flux and energy released during the detected flares. Accepted by A&A *For preprints contact*: icc@astrax.fis.ucm.es
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Rotational Mixing in Low Mass Stars. II. Self-consistent Models of Pop II RGB Stars

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In this paper we study the effects of rotation in low-mass, low-metallicity RGB stars. We present the first evolutionary models taking into account self-consistently the latest prescriptions for the transport of angular momentum by meridional circulation and shear turbulence in stellar interiors as well as the associated mixing processes for chemicals computed from the ZAMS to the upper RGB. We discuss in details the uncertainties associated with the physical description of the rotational mixing and study carefully their effects on the rotation profile, diffusion coefficients, structural evolution, lifetimes and chemical signatures at the stellar surface. We focus in particular on the various assumptions concerning the rotation law in the convective envelope, the initial rotation velocity distribution, the presence of μ-gradients and the treatment of the horizontal and vertical turbulence.

This exploration leads to two main conclusions: (1) After the completion of the first dredge-up, the degree of differential rotation (and hence mixing) is maximised in the case of a differentially rotating convective envelope (i.e., $j_{CE}(r) = cst$), as anticipated in previous studies. (2) Even with this assumption, and contrary to some previous claims, the present treatment for the evolution of the rotation profile and associated meridional circulation and shear turbulence does not lead to enough mixing of chemicals to explain the abundance anomalies in low-metallicity field and globular cluster RGB stars observed around the *bump* luminosity. This study raises questions that need to be addressed in a near future. These include for example the interaction between rotation and convection and the trigger of additional hydrodynamical instabilities.

Accepted by Astronomy & Astrophysics

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For preprints via ftp or WWW: http://fr.arxiv.org/abs/astro-ph/0602389

Opacity in the Upper Atmospheres of Active Stars II. AD Leonis

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We present FUV and UV spectroscopic observations of AD Leonis, with the aim of investigating opacity effects in the transition regions of late–type stars. The C III lines in *FUSE* spectra show significant opacity during both the quiescent and flaring states of AD Leonis, with up to 30% of the expected flux being lost during the latter. Other *FUSE* emission lines tested for opacity include those of O VI, while C IV, Si IV and N V transitions observed with STIS are also investigated. These lines only reveal modest amounts of opacity with losses during flaring of up to 20%. Optical depths have been calculated for homogeneous and inhomogeneous geometries, giving path lengths of ≈20–60 km and ≈10–30 km, respectively, under quiescent conditions. However path lengths derived during flaring are ≈2–3 times larger. These values are in excellent agreement with both estimates of the small-scale structure observed in the solar transition region, and path lengths derived previously for several other active late-type stars.

Accepted by A&A

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Testing the Companion Hypothesis for the Origin of the X-ray Emission from Intermediate-mass Main-sequence Stars

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The X-ray emission from B-type main-sequence stars is a longstanding mystery in stellar coronal research. Since there is no theory at hand that explains intrinsic X-ray emission from intermediate-mass main-sequence stars, the observations have often been interpreted in terms of (unknown) late-type magnetically active companion stars. Resolving the hypothesized companions requires high spatial resolution observations in the infrared and in X-rays. We use Chandra imaging observations to spatially resolve a sample of main-sequence B-type stars with recently discovered companions at arcsecond separation. Our strategy is to search for X-ray emission at the position of both the B-type primary and the faint companion. We find that all spatially resolved companions are X-ray emitters, but seven out of eleven intermediate-mass stars are also X-ray sources. If this emission is interpreted in terms of additional sub-arcsecond or spectroscopic companions, this implies a high multiplicity of B-type stars. Firm results on B star multiplicity pending, the alternative, that B stars produce intrinsic X-rays, can not be discarded. The appropriate scenario in this vein is probably a magnetically confined wind, as suggested for the X-ray emission of the magnetic Ap star IQ Aur. However, the only Ap star in the Chandra sample is not detected in X-rays, and therefore does not support this picture.

Accepted by A&A

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The Remarkable Far-Ultraviolet Spectrum of FK Comae Berenices: King of Spin

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A *Far-Ultraviolet Spectroscopic Explorer* (*FUSE*) pointing on the ultra-fast rotating yellow giant FK Comae Berenices

(HD 117555; $v \sin i \sim 163$ km s^{-1}), recorded emission profiles of C III $\lambda 977$ ($T \sim 8 \times 10^4$ K) and O VI $\lambda 1031$ ($T \sim 3 \times 10^5$ K) which are exceptionally broad, asymmetric, but nearly identical in shape, aside from a blueward absorption component in the latter (identified as interstellar O I, rather than, say, a C III outflow feature). The full widths at half maximum intensity (FWHM) exceed 500 km s^{-1}, *twice* the broadest FUV lineshape of any normal late-type star observed to date; but similar to the Hα profiles of FK Com, and following the trend of other fast spinning early-G giants which often display "super-rotational" broadening of their UV "hot" lines. Although the red-asymmetric O VI $\lambda 1031$ profile is suggestive of an outflow at $\sim 3 \times 10^5$ K, the weaker member of the doublet—$\lambda 1037$—does not display the differential absorption pattern expected from a warm wind. Furthermore, at times the chromospheric Mg II $\lambda 2796 + \lambda 2803$ composite profile, from a collection of *International Ultraviolet Explorer* (*IUE*) echellograms obtained two decades earlier, is nearly identical in shape to red-asymmetric O VI $\lambda 1031$. A contemporaneous optical Doppler map places the photospheric dark spots mainly in the polar regions of the approaching hemisphere. The dominantly redward biased profiles of C III and O VI could be explained if the associated emission zones were *leading* the starspots in phase, and partially rooted in lower latitudes.

Accepted by ApJ

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Solar Abstracts

Forecasting Solar Wind Speeds

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By explicitly taking into account effects of Alfven waves, I derive from a simple energetics argument a fundamental relation which predicts solar wind (SW) speeds in the vicinity of the earth from physical properties on the sun. Kojima et al. recently found from their observations that a ratio of surface magnetic field strength to an expansion factor of open magnetic flux tubes is a good indicator of the SW speed. I show by using the derived relation that this nice correlation is an evidence of the Alfven wave which accelerates SW in expanding flux tubes. The observations further require that fluctuation amplitudes of magnetic field lines at the surface should be almost universal in different coronal holes, which needs to be tested by future observations.

Accepted by ApJL

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Solar Winds Driven by Nonlinear Low-Frequency Alfvén Waves from the Photosphere : Parametric Study for Fast/Slow Winds and Disappearance of Solar Winds

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We investigate how properties of the corona and solar wind in open coronal holes depend on properties of magnetic fields and their footpoint motions at the surface. We perform one-dimensional magnetohydrodynamical (MHD) simulations for the heating and the acceleration in coronal holes by low-frequency Alfvén waves from the photosphere to 0.3 or 0.1AU. We impose low-frequency (≤ 0.05 Hz) transverse fluctuations of the field lines at the photosphere with various amplitude, spectrum, and polarization in the open flux tubes with different photospheric field strength, $B_{r,0}$, and super-radial expansion of the cross section, $f_{\rm max}$. We find that transonic solar winds are universal consequences. The atmosphere is also stably heated up to $\geq 10^6$K by the dissipation of the Alfvén waves through compressive-wave generation and wave reflection in the cases of the sufficient wave input with photospheric amplitude, $\langle dv_{\perp,0}\rangle \geq 0.7$ km s^{-1}. The density, and accordingly the mass flux, of solar winds show a quite sensitive dependence on $\langle dv_{\perp,0}\rangle$ because of an unstable aspect of the heating by the nonlinear Alfvén waves. A case with $\langle dv_{\perp,0}\rangle = 0.4$km s^{-1} gives $\simeq$50 times

smaller mass flux than the fiducial case for the fast wind with $\langle dv_{\perp,0}\rangle = 0.7$km s^{-1}; solar wind *virtually disappears* only if $\langle dv_{\perp,0}\rangle$ becomes $\simeq$1/2. We also find that the solar wind speed has a positive correlation with $B_{r,0}/f_{\rm max}$, which is consistent with recent observations by Kojima et al. Based on these findings, we show that both fast and slow solar winds can be explained by the single process, the dissipation of the low-frequency Alfvén waves, with different sets of $\langle dv_{\perp,0}\rangle$ and $B_{r,0}/f_{\rm max}$. Our simulations naturally explain the observed (i) anti-correlation of the solar wind speed and the coronal temperature and (ii) larger amplitude of Alfvénic fluctuations in the fast wind. In Appendix, we also explain our implementation of the outgoing boundary condition of the MHD waves with some numerical tests.

Accepted by J. Geophys. Res.

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Magneto-convection in a Sunspot Umbra

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Results from a realistic simulation of 3D radiative magneto-convection in a strong background magnetic field corresponding to the conditions in sunspot umbrae are shown. The convective energy transport is dominated by narrow upflow plumes with adjacent downflows, which become almost field-free near the surface layers. The strong external magnetic field forces the plumes to assume a cusp-like shape in their top parts, where the upflowing plasma loses its buoyancy. The resulting bright features in intensity images correspond well (in terms of brightness, size, and lifetime) to the observed umbral dots in the central parts of sunspot umbrae. Most of the simulated umbral dots have a horizontally elongated form with a central dark lane. Above the cusp, most plumes show narrow upflow jets, which are driven by the pressure of the piled-up plasma below. The large velocities and low field strengths in the plumes are effectively screened from spectroscopic observation because the surfaces of equal optical depth are locally elevated, so that spectral lines are largely formed above the cusp. Our simulations demonstrate that nearly field-free upflow plumes and umbral dots are a natural result of convection in a strong, initially monolithic magnetic field.

Accepted by ApJ Letters

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Identification of the Broad Solar Emission Features Near 117 nm

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Wilhelm et al. have recently called attention to the unidentified broad emission features near 117 nm in the solar spectrum. They discuss the observed properties of these features in detail but do not identify the source of this emission.

We show that the broad autoionizing transitions of neutral sulfur are responsible for these emission features. Autoionizing lines of S I occur throughout the spectrum between Lyman alpha and the Lyman limit. Sulfur is a normal contributor to stellar spectra.

We use non-LTE chromospheric model calculations with line data from the Kurucz 2004 S I line list to simulate the solar spectrum in the range 116 to 118 nm. We compare the results with SUMER disk-center observations from Curdt et al. and limb observations from Wilhelm et al.

Our calculations generally agree with the SUMER observations of the broad autoionizing S I emission features, the narrow S I emission lines, and the continuum in this wavelength region, and agree with basic characteristics of the center-to-limb observations. In addition to modeling the average spectrum, we show that a change of ± 200 K in the temperature distribution causes the intensity to change by a factor of 4. This exceeds the observed intensity variations 1) with time in quiet regions at these wavelengths, and 2) with position from cell centers to bright network. These results do not seem compatible with current dynamical models that have temporal variations of 1000 K or more in the low chromosphere. (cont. →)

Accepted by A&A

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Low-Mass and Substellar Abstracts

Measuring Magnetic Fields in Ultracool Stars and Brown Dwarfs

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We present a new method for direct measurement of magnetic fields on ultracool stars and brown dwarfs. It takes advantage of the Wing-Ford band of FeH, which are seen throughout the M and L spectral types. These molecular features are not as blended as other optical molecular bands, are reasonably strong through most of the spectral range, and exhibit a response to magnetic fields which is easier to detect than other magnetic diagnostics, including the usual optical and near-infrared atomic spectral lines that have heretofore been employed. The FeH bands show a systematic growth as the star gets cooler. We do not find any contamination by CrH in the relevant spectral region. We are able to model cool and rapidly-rotating spectra from warmer, slowly-rotating spectra utilizing an interpolation scheme based on optical depth scaling. We show that the FeH features can distinguish between negligible, moderate, and high magnetic fluxes on low-mass dwarfs, with a current accuracy of about one kilogauss. Two different approaches to extracting the information from the spectra are developed and compared. Which one is superior depends on a number of factors. We demostrate the validity of our new procedures by comparing the spectra of three M stars whose magnetic fluxes are already known from atomic line analysis. The low and high field stars are used to produce interpolated moderate-strength spectra which closely resemble the moderate-field star. The assumption of linear behavior for the magnetic effects appears to be reasonable, but until the molecular constants are better understood the method is subject to that assumption, and rather approximate. Nonetheless, it opens a new regime of very low-mass objects to direct confirmation and testing of their magnetic dynamos.

Accepted by ApJ

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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

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