COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

The First Close-up of the "Flip-Flop" Phenomenon in a Single Star

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We present temperature maps of the active late-type giant FK Com which exhibit the first imaging record of the "flip-flop" phenomenon in a single star. The phenomenon, in which the main part of the spot activity shifts 180° in longitude, discovered a decade ago in FK Com, was reported later also in a number of RS CVn binaries and a single young dwarf. With the surface images obtained right before and after the "flip-flop", we clearly show that the "flip-flop" phenomenon in FK Com is caused by changing the relative strengths of the spot groups at the two active longitudes, with no actual spot movements across the stellar surface, i.e. exactly as it happens in other active stars.

Accepted by A&A Letters

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The Faint End of the Stellar Luminosity Function: The Palomar Large-Area CCD Survey

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The luminosity function for late type stars in the field is determined from long, thin images of the sky observed with the Palomar 5 m telescope operated in time-delay-and-integrate mode. Two custom broad-band filters were used, with central wavelengths of 7200 and 9500 Å, yielding limiting magnitudes for point sources corresponding to $R = 22$ and

$I = 20$. Images cover 37 square degrees, sampling Galactic latitudes from $-60°$ to $-25°$ and $+25°$ to $+78°$. Over a million objects were discovered; 24,652 of these objects were cataloged as M dwarf candidates and used to derive the luminosity function. Standard *VRI* magnitudes were measured for stars in 5.1% of the survey area, allowing Palomar measurements to be transformed to standard *VRI* magnitudes. Classification spectra were obtained for 282 of the stars in the survey, confirming the relationship between color and Spectral Type. The contamination rate by non-dwarfs in the color range $+1.1 < V - I < +4.1$ was less than 1%. Distances were estimated based on absolute M_I magnitudes for stars, inferred $V - I$ color, and I apparent magnitude.

To model the selection effects present in the catalog and derive empirical estimates of the uncertainties in the desired parameters, Monte Carlo simulations of the survey, using a model Galaxy, were created. The local stellar luminosity function was determined by adjusting the model input parameters to yield an artificial catalog which best matched the observed catalog. The luminosity function is presented for absolute magnitudes in the range $7 < M_I < 14$. This study agrees with previous measurements for $M_I < 11$, but has significantly smaller error bars. For M_I near 12, a higher number density is measured than has been reported for previous photometric studies. The LF was converted to the V-band for further direct comparison to previous studies. The corresponding Mass Function is slowly rising for decreasing mass near the brown dwarf limit of 0.08 solar masses.

Submitted to AJ

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Chromospheric Activity, Lithium and Radial Velocities of Single Late-type Stars Possible Members of Young Moving Groups

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We present here high resolution echelle spectra taken during three observing runs of 14 single late-type stars identified in our previous studies (Montes et al. 2001b, hereafter Paper I) as possible members of different young stellar kinematic groups (Local Association (20 - 150 Myr), Ursa Major group (300 Myr), Hyades supercluster (600 Myr), and IC 2391 supercluster (35 Myr)). Radial velocities have been determined by cross correlation with radial velocity standard stars and used together with precise measurements of proper motions and parallaxes taken from Hipparcos and Tycho-2 Catalogues, to calculate Galactic space motions (U, V, W) and to apply Eggen's kinematic criteria. The chromospheric activity level of these stars have been analysed using the information provided for several optical spectroscopic features (from the Ca II H & K to Ca II IRT lines) that are formed at different heights in the chromosphere. The Li I λ6707.8 Å line equivalent width (EW) has been determined and compared in the EW(Li I) versus spectral type diagram with the EW(Li I) of stars members of well-known young open clusters of different ages, in order to obtain an age estimation. All these data allow us to analyse in more detail the membership of these stars in the different young stellar kinematic groups. Using both, kinematic and spectroscopic criteria we have confirmed PW And, V368 Cep, V383 Lac, EP Eri, DX Leo, HD 77407, and EK Dra as members of the Local Association and V834 Tau, π^1 UMa, and GJ 503.2 as members of the Ursa Major group. A clear rotation-activity dependence has been found in these stars.

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http://www.ucm.es/info/Astrof/skg/skg_catalogue.html

X-ray Doppler Imaging of 44ι Boo with *Chandra*

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Chandra High-Energy Transmission Grating observations of the bright eclipsing contact binary 44ι Boo show X-ray line profiles which are Doppler-shifted by orbital motions. The X-ray emission spectrum contains a multitude of lines superimposed on a weak continuum, with strong lines of O VIII, Ne X, Fe XVII, and Mg XII. The profiles of these lines from the total observed spectrum show Doppler-broadened widths of $\sim$ 550 km s^{-1}. Line centroids vary with orbital phase, indicating velocity changes of $>$ 180 km s^{-1}. The first-order light curve shows significant variability, but no clear evidence for either primary or secondary eclipses. Flares are observed for all spectral ranges; additionally, the light curve constructed near the peak of the emission measure distribution ($T_e = 5$ to 8×10^6 K) shows quiescent variability as well as flares. The phase-dependences of line profiles and light curves together imply that at least half of the emission is localized at high latitude. A simple model with two regions on the primary star at relatively high latitude reproduces the observed line profile shifts and quiescent light curve. These first clear X-ray Doppler shifts of stellar coronal material illustrate the power of *Chandra*.

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Astrometric Radial Velocities. III. Hipparcos Measurements of Nearby Star Clusters and Associations

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Radial motions of stars in nearby moving clusters are determined from accurate proper motions and trigonometric parallaxes, without any use of spectroscopy. Assuming that cluster members share the same velocity vector (apart from a random dispersion), we apply a maximum-likelihood method on astrometric data from Hipparcos to compute radial and space velocities (and their dispersions) in the Ursa Major, Hyades, Coma Berenices, Pleiades, and Praesepe clusters, and for the Scorpius-Centaurus, alpha Persei, and 'HIP 98321' associations. The radial motion of the Hyades cluster is determined to within 0.47 of the Hyades cluster is determined to within 0.47 km/s (standard error), and that of its individual stars to within 0.6 km/s. For other clusters, Hipparcos data yield astrometric radial velocities with typical accuracies of a few km/s. A comparison of these astrometric values with spectroscopic radial velocities in the literature shows a good general agreement and, in the case of the best-determined Hyades cluster, also permits searches for subtle astrophysical differences, such as evidence for enhanced convective blueshifts of F-dwarf spectra, and decreased gravitational redshifts in giants. Similar comparisons for the Scorpius OB2 complex indicate some expansion of its associations, albeit slower than expected from their ages. As a by-product from the radial-velocity solutions, kinematically improved parallaxes for individual stars are obtained, enabling Hertzsprung-Russell diagrams with unprecedented accuracy in luminosity. For the Hyades (parallax accuracy 0.3 mas), its main sequence resembles a thin line, possibly with wiggles in it. Although this main sequence has underpopulated regions at certain colours (previously suggested to be 'Böhm-Vitense gaps'), such are not visible for other clusters, and are probably spurious. Future space astrometry missions carry a great potential for absolute radial-velocity determinations, insensitive to the complexities of stellar spectra.

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New Neighbours: IV. 30 DENIS Late-M dwarfs Between 15 and 30 Parsecs

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We present 30 new nearby ($d < 30$ pc) red dwarf candidates, with estimated spectral types M6 to M8. 26 were directly selected from the DENIS database, and another 4 were first extracted from the LHS catalogue and cross-identified with a DENIS counterpart. Their proper motions were measured on the MAMA measuring machine from plates spanning 13 to 48 years, and are larger than 0.1" yr^{-1}, ruling out the possibility that they are giants. Their distances were

estimated from the DENIS colours and IR colour-magnitude relations and range between 15 and 30 pc.

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Photometric and TiO Modelling of the Starspots on AG Dor and HU Vir

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In this work, spot parameters are determined for two stars, namely, AG Dor and HU Vir, from their photometric variability and λ7055 Å TiO band depth. Applying the photometric modelling code SPOTPIC, we have found two modulating spots together with a non-modulating component on the photosphere of AG Dor in December 96/January 97. The spot temperatures are constrained to be between 4300 K and 4600 K for the modulating component, and cooler, viz., 4000 K, for the non-modulating one. Therefore, the non-modulating component of the spot distribution on AG Dor at this epoch is held to be totally responsible for the presence of the TiO band in the spectra of this K1 dwarf with photospheric temperature of 5000 K. AG Dor's total coverage of spots is determined to be between 4% and 7% for the modulating component and 26.5% for the non-modulating one. For HU Vir, the light and colour curves were modelled with two spots with temperatures of 4450 and 4050 K. In this case we did not include the non-modulating component in the model.

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Chemical Composition of Red Horizontal Branch Stars in the Thick Disk of the Galaxy

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High-resolution spectra of 13 core helium-burning stars in the thick disk of the Galaxy have been obtained with the SOFIN spectrograph on the Nordic Optical Telescope to investigate abundances of up to 22 chemical elements. Abundances of carbon were studied using the C_2 Swan (0,1) band head at 5635.5 Å. The wavelength interval 7980–8130 Å with strong CN features was analysed in order to determine nitrogen abundances and $^{12}C/^{13}C$ isotope ratios. The oxygen abundances were determined from the [O I] line at 6300 Å. Abundances in the investigated stars suggest that carbon is depleted by about 0.3 dex, nitrogen is enhanced by more than 0.4 dex and oxygen is unaltered. The $^{12}C/^{13}C$ ratios are lowered and lie between values 3 and 7 which is in agreement with "cool bottom processing" predictions (Boothroyd & Sackmann 1999). The C/N ratios in the investigated stars are lowered to values between 0.7 and 1.2 which is less than present day theoretical predictions and call for further studies of stellar mixing processes. Abundance ratios of O, Mg, Eu and other heavy chemical elements to iron in the investigated stars show a pattern characteristic of thick disk stars. The results provide evidence that the thick disk population has a distinct chemical history from the thin disk. The onset of the bulk of SN Ia is suggested to appear at [Fe/H]≈ -0.6 dex.

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Modelling Surface Magnetic Field Evolution on AB Doradûs Due to Diffusion and Surface Differential Rotation

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From Zeeman Doppler images of the young, rapidly-rotating K0 dwarf AB Doradûs, we have created a potential approximation to the observed radial magnetic field and have evolved it over 30 days due to the observed surface differential rotation, meridional flow and various diffusion rates. Assuming that the dark polar cap seen in Doppler images of this star is caused by the presence of a unipolar field, we have shown that the observed differential rotation will shear this field to produce the observed high-latitude band of unidirectional azimuthal field. By cross-correlating the evolved fields each day with the initial field we have followed the decay with time of the cross-correlation function. Over 30 days it decays by only 10%. This contrasts with the results of Barnes *et al* (1998) who show that on this timescale the spot distribution of He699 is uncorrelated. We propose that this is due to the effects of flux emergence changing the spot distributions.

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Spectroscopic Signatures of Convection in the Spectrum of Procyon. Fundamental Parameters and Iron Abundance.

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We have observed the spectrum of Procyon A (F5IV) from 4559 to 5780 Å with a S/N of $\sim 10^3$ and a resolving power of 2×10^5. We have measured the line bisectors and relative line shifts of a large number of Fe I and Fe II lines, comparing them to those found in the Sun. A three-dimensional (3D) hydrodynamical model atmosphere has been computed and is tested against observations. The model reproduces in detail most of the features observed, although we identify some room for improvement. At all levels, the comparison of the 3D time-dependent calculations with the observed spectral lines shows a much better agreement than for classical homogeneous models, making it possible to refine previous estimates of the iron abundance, the projected rotational velocity, the limb-darkening, and the systemic velocity of the Procyon binary system. The difference between the iron abundance determined with the 3D model and its 1D counterpart is ≤ 0.05 dex. We find consistency between the iron abundance derived from Fe I and Fe II lines, suggesting that departures from LTE in the formation of the studied lines are relatively small. The scatter in the iron abundance determined from different lines still exceeds the expectations from the uncertainties in the atomic data, pointing out that one or more components in the modeling can be refined further.

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Solar Abstracts

Kinetic Equilibrium of Iron in the Atmospheres of Cool Dwarf Stars II. Weak FeI Lines in the Solar Spectrum

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NLTE line formation calculations of FeI in the solar atmosphere are extended to include weak lines in the visual spectrum of the Sun. Previously established atomic models are used to discriminate between different ways of treating collisional interaction processes. As indicated by the analysis of strong FeI lines, the influence of deviations from LTE in the solar atmosphere on the Fe abundance is small for all lines. To derive a common *solar* FeI abundance from both strong *and* weak lines fine-tuning of the microturbulence velocity parameter and the van-der-Waals damping constants is required. The solar FeI abundances based on all available f-values are dominated by the large scatter

already found for the stronger lines. In particular the bulk of the data from the work of May et al. and O'Brian et al. is not adequate for accurate abundance work. Based on f-values measured by the Hannover and Oxford groups alone, the FeI LTE abundances are $\varepsilon(\mathrm{FeI},\odot) = 7.57$ for the empirical and $\varepsilon(\mathrm{FeI},\odot) = 7.48\ldots7.51$ for the line-blanketed solar model. The solar Fe ionization equilibrium obtained for different atomic and atmospheric models rules out NLTE atomic models with a low efficiency of hydrogen collisions. At variance with Paper I, it is now in better agreement with *laboratory* FeII f-values for all types of line-blanketed models. Our final model assumptions consistent with a *single* unique solar Fe abundance $\varepsilon(\mathrm{Fe},\odot) \sim 7.48\ldots7.51$ calculated from NLTE line formation are (a) a line-blanketed solar model atmosphere, (b) an iron model atom with hydrogen collision rates $0.5 < \mathrm{S_H} < 5$ times the standard value to compensate for the large photoionization cross-sections, (c) a microturbulence velocity $\xi = 1.0$ km/s, (d) van-der-Waals damping parameters decreased by $\Delta \log C_6 = -0.10\ldots-0.15$ as compared to Anstee & O'Mara's calculations, depending on $\mathrm{S_H}$, (e) FeII f-values as published by Schnabel et al., and (f) FeI f-values published by the Hannover and Oxford groups.

Accepted by A&A

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Zeeman-split Opposite-polarity OH Lines in Sunspot Spectra: Resolution of a Puzzle

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We present the first synthetic Zeeman-split Stokes I and V profiles of OH lines. They explain the puzzling observations reported by Harvey (1985) of two pairs of lines from the infrared (2,0) band with Stokes V profiles exhibiting opposite polarities. Our new perturbation calculations of the Zeeman effect in diatomic molecules, which allow states of any multiplicity to be treated, resolve the puzzle. They reveal that the unusual behaviour of these lines stems from the fact that the two pairs have effective Landé factors of similar magnitude, but of opposite signs.

Accepted by A&A

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Improving the Numerical Modeling of the O I Resonance Triplet in the Solar Spectrum

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We present a slight modification to an existing multi-level radiative transfer code that allows us to include the effects of frequency cross-redistribution (XRD) between lines sharing the same upper level. With this improved code we calculate theoretical profiles of the O I resonance triplet lines at 130 nm through a hydrostatic model of the average quiet Sun. The width of the calculated XRD profiles show good agreement with an observed spatially averaged disk-center spectrum obtained with the HRTS spectrograph. This is in stark contrast to profiles calculated with complete frequency redistribution (CRD) and ordinary partial frequency redistribution (PRD), which have Lorentzian wings that are too broad. We find deep central reversals, contrary to most observed profiles, but note that this discrepancy is to a large degree the result of limited instrumental spectral resolution.

Accepted by ApJ

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The CORALIE Survey for Southern Extra-solar Planets VI. New Long Period Giant Planets Around HD 28185 and HD 213240

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In this paper we present giant planetary companions to the stars HD 28185 and HD 213240. Both candidates were discovered in the context of the CORALIE extra-solar planet search programme. The planet around HD 28185, with a minimum mass of 5.7 M_{Jup} is one of the first long period planets (P=383 days) discovered so far orbiting its host star in a nearly circular trajectory. On the other hand, the planet around HD 213240, with a 951-day period orbit, an eccentricity of 0.45, and a minimum mass of 4.5 M_{Jup}, is more typical of the up to now discovered long period systems.

Accepted by A&A

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UPCOMING MEETING

Stellar Abundances and Nucleosynthesis

March 27 - 29, 2002
Univ. of Washington
Seattle, WA

The Institute for Nuclear Theory and the Astronomy Department of the University of Washington are pleased to announce a conference on *Stellar Abundances and Nucleosynthesis* to be held at the Univ. of Washington on March 27 - 29, 2002. This conference will celebrate the demonstration that some stars are deficient in heavy elements by Chamberlain and Aller, as well as the discovery of the unstable element technetium by P.W. Merrill, both in 1951.

Topics that will be emphasized are:

Abundances of light elements i.e. D to B,
Globular clusters and mixing in stars,
Fe-peak elements and their production,
R-process and S-process elements,
and QSO absorption lines.

For further information see:

http://int.phys.washington.edu /PROGRAMS/spring.html

Submitted by: George Wallerstein (wall@astro.washington.edu)

JOB OPENING

Postdoctoral Position
High-Energy Astrophysics
Smithsonian Astrophysical Observatory
Cambridge, MA

The Smithsonian Astrophysical Observatory has a postdoctoral position, not to exceed two years initially with the possibility of extension, available for a Ph.D. physicist or astrophysicist. Consideration of applications will begin October 23, 2001 and will remain open until a suitable candidate is found.

The Research Astrophysicist will participate in a program of research with Dr. Nancy Brickhouse on stellar and interstellar plasmas with emphasis on x-ray emission lines. The research also incorporates studies of infrared, optical, ultraviolet, and extreme ultraviolet spectra of these plasmas. The investigation will test the applicability and accuracy of available plasma emission models for analyzing and interpreting high energy spectra. The overall aims of the project are to improve physical models of the emitting regions and to assess the needs for more accurate inputs, particularly atomic data needs. The work includes data reduction and analysis of spectral data from Chandra, XMM-Newton, FUSE, and others for stellar coronae and other collisionally ionized astrophysical sources; developing, and verifying data analysis software; preparing papers for publication; and presenting research results at conferences.

More information can be obtained at

http://cfa-www.harvard.edu/cfa/hr/postings/22-03.htm

Interested applicants should reference Job Code 22-03CN and submit curriculum vitae, bibliography, a brief description of research interests, and the names, addresses, email addresses, and telephone numbers of three professional references to the address below, or via email at saoresumes@cfa.harvard.edu.

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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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