COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Inelastic H+Li and H^-+Li^+ Collisions and Non-LTE Li I Line Formation in Stellar Atmospheres

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Rate coefficients for inelastic collisions between Li and H atoms covering all transitions between the asymptotic states Li($2s$,$2p$,$3s$,$3p$,$3d$,$4s$, $4p$,$4d$,$4f$)+H($1s$) and Li^++H^- are presented for the temperature range 2000–8000 K based on recent cross-section calculations. The data are of sufficient completeness for non-LTE modelling of the Li I 670.8 nm and 610.4 nm features in late-type stellar atmospheres. Non-LTE radiative transfer calculations in both 1D and 3D model atmospheres have been carried out for test cases of particular interest. Our detailed calculations show that the classical modified Drawin-formula for collisional excitation and de-excitation ($Li^*+H \rightleftharpoons Li^{*\prime}+H$) over-estimates the cross-sections by typically several orders of magnitude and consequently that these reactions are negligible for the line formation process. However, the charge transfer reactions collisional ion-pair production and mutual neutralization ($Li^*+H \rightleftharpoons Li^++H^-$) are of importance in thermalizing Li. In particular, 3D non-LTE calculations of the Li I 670.8 nm line in metal-poor halo stars suggest that 1D non-LTE results over-estimate the Li abundance by up to about 0.1 dex, aggrevating the discrepancy between the observed Li abundances and the primordial Li abundance as inferred by the WMAP analysis of the cosmic microwave background.

Accepted by A&A Letters

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For preprints via WWW: http://xxx.lanl.gov/abs/astro-ph/0308170

Modeling the Ne IX Triplet Spectral Region of Capella with the Chandra and XMM-Newton Gratings

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High resolution X-ray spectroscopy with the diffraction gratings of Chandra and XMM-Newton offers new chances to study a large variety of stellar coronal phenomena. A popular X-ray calibration target is Capella, which has been observed with all gratings with significant exposure times. We gathered together all available data of the HETGS (155 ks), LETGS (219 ks), and RGS (53 ks) for comparative analysis focusing on the Ne IX triplet at around 13.5 Å, a region that is severely blended by strong iron lines. We identify 18 emission lines in this region of the HEG spectrum, including many from Fe XIX, and find good agreement with predictions from a theoretical model constructed using the Astrophysical Plasma Emission Code (APEC). The model uses an emission measure distribution derived from Fe XV to Fe XXIV lines. The success of the model is due in part to the inclusion of accurate wavelengths from laboratory measurements. While these 18 emission lines cannot be isolated in the LETGS or RGS spectra, their wavelengths and fluxes as measured with HEG are consistent with the lower resolution spectra.

In the Capella model for HEG, the weak intercombination line of Ne IX is significantly blended by iron lines, which contribute about half the flux. After accounting for blending in the He-like diagnostic lines, we find the density to be consistent with the low density limit ($n_e < 2 \times 10^{10}$ cm^{-3}); however, the electron temperature indicated by the Ne IX G-ratio is surprisingly low (~ 2 MK) compared with the peak of the emission measure distribution (~ 6 MK). Models show that the Ne IX triplet is less blended in cooler plasmas and in plasmas with an enhanced neon-to-iron abundance ratio.

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For preprints via WWW: http://xxx.soton.ac.uk/abs/astro-ph/0308317

A Spatially Resolved Limb Flare on Algol B Observed with XMM-Newton

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We report XMM-Newton observations of the eclipsing binary Algol A (B8V) and B (K2III). The XMM-Newton data cover the phase interval 0.35 – 0.58, i.e., specifically the time of optical secondary minimum, when the X-ray dark B-type star occults a major fraction of the X-ray bright K-type star. During the eclipse a flare was observed with complete light curve coverage. The decay part of the flare can be well described with an exponential decay law allowing a rectification of the light curve and a reconstruction of the flaring plasma region. The flare occurred near the limb of Algol B at a height of about 0.1 $R_\star$ with plasma densities of a few times 10^{11} cm^{-3} consistent with spectroscopic density estimates. No eclipse of the quiescent X-ray emission is observed leading us to the conclusion that the overall coronal filling factor of Algol B is small.

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Magnetic Activity of Six Young Solar Analogues
II. Surface Differential Rotation from Long-term Photometry

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The present paper is the second of a series dedicated to the study of the magnetic activity in a selected sample of young solar analogues. The sample includes five single G0-G5V stars with ages between $\simeq$ 130 Myr and 700 Myr: EK Dra, π^1 UMa, HN Peg, k^1 Cet and BE Cet. In this study we also include the Pleiades-age ($\simeq$ 130 Myr) K0V star DX Leo. Our analysis is based on high precision photometric observations carried out as part of *The Sun in Time* project, aimed at a multiwavelength study of stars with solar-like global properties, but with different ages and thus at different stages of evolution. In the first papers of this series we presented the photometric observations and determined the existence of starspot cycles and their correlation with the global stellar properties. In the present paper we investigate the surface differential rotation (SDR). The periodogram analysis of the photometric data time series has allowed us to determine the rotational periods and to derive the following results: *i)* all the selected stars show variations of the rotational period. Such variations are definitely periodic and in phase with the starspot cycle for BE Cet and DX Leo. They are likely periodic and in phase also for π^1 UMa, EK Dra and HN Peg, but still need confirmation. By analogy with the solar butterfly diagram, the rotational period variations are interpretable in terms of surface differential rotation, that is, they are attributable to the existence of active latitude belts migrating during the activity cycle on a differentially rotating star; *ii)* BE Cet, π^1 UMa and EK Dra show a solar-like pattern of SDR, that is the rotational period steadily decreases along the activity cycle, jumping back to higher values at the beginning of the next cycle; on the contrary, DX Leo, k^1 Cet and HN Peg show an antisolar pattern; *iii)* the amplitude of the rotational period variations shows a power law dependence on the rotational period similar to that found in previous studies. Contrary to theoretical predictions, the cycle length is not correlated to the Dynamo number, it is indeed positively correlated to the SDR amplitude. More precisely, stars tend to concentrate along three different branches with the cycle length increasing with increasing $\Delta\Omega/\Omega$. Moreover, we found that the SDR amplitude changes from cycle to cycle, which is reminiscent of a wave of excess rotation propagating in latitude; *iiii)* the apparently different solar and antisolar behaviours are probably due to different inclinations of the stellar rotation axis under which the star is seen. The long-term photometry of the young single star LQ Hya, although not included in the initial project, is also used in the present analysis to enlarge the investigated sample. We determined for LQ Hya three different starspot cycles and an antisolar pattern of SDR.

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Dependence of Coronal X-ray Emission on Spot-induced Brightness Variations in Cool Main Sequence Stars

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The maximum amplitude (A_{max}) of spot-induced brightness variations from long-term V-band photometry and the ratio L_X/L_{bol} between X-ray and bolometric luminosities are suitable indicators of the level of magnetic activity in the photosphere and in the corona of late-type stars, respectively. By using these activity indicators we investigate the dependence of coronal X-ray emission on the level of photospheric starspot activity in a homogeneous sample of low mass main sequence field and cluster stars of different ages (IC 2602, IC 4665, IC 2391, α Persei, Pleiades and Hyades). First, the activity-rotation connection at the photospheric level is re-analysed, as well as its dependence on spectral type and age. The upper envelope of A_{max} increases monotonically with decreasing rotational period (P) and Rossby number (R_0) showing a break around 1.1 d that separates two rotation regimes where the starspot activity shows different behaviours. The A_{max}-P and A_{max}-R_0 relations are fitted with linear, exponential and power laws to look for the function which best represents the trend of the data. The highest values of A_{max} are found among K-type stars and at the ages of α Persei and Pleiades. We also analyse the activity-rotation connection at the coronal level as well as its dependence on spectral type. The level of X-ray emission increases with increasing rotation rate up to a saturation level. The rotational period at which saturation occurs is colour-dependent and increases with advancing spectral type. Also the L_X/L_{bol}-P and L_X/L_{bol}-R_0 relations are fitted with linear, exponential and power laws to look for the best fitting function. Among the fastest rotating stars (P$\leq$ 0.3 d) there is evidence of super-saturation. Also the highest values of L_X/L_{bol} are found among K-type stars. Finally, the photospheric-coronal activity connection is investigated by using for the first time the largest ever sample of light curve amplitudes as indicators of the magnetic filling factor. The activity parameters L_X/L_{bol} and A_{max} are found to be correlated with each other, thus confirming the dependence of coronal activity on photospheric magnetic fields. More precisely, the L_X/L_{bol}-A_{max} distribution shows the presence of an upper envelope, which is constant at the $L_X/L_{bol} \simeq -3.0$ saturation level, and of a lower envelope. The best fit to the lower envelope is given by a power law with steepness decreasing from F-G to M spectral types. However, it is considered a tentative result, since the fit reduced chi-squares are large. Such spectral-type dependence may be related to a colour dependence of A_{max} on the total starspot filling factor, as well as to the coronal emission being possibly more sensitive to starspot activity variations in F- and G-type than in M-type stars. The L_X/L_{bol}-A_{max} mean values for each cluster in our sample decrease monotonically with increasing age, showing that the levels of photospheric and coronal activity evolve in time according to a single power law till the Sun's age.

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On The Filling Factor Of Emitting Material In The Upper Atmosphere Of ϵ Eri (K2 V)

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The emission measure distribution in the upper transition region and corona of ϵ Eri is derived from observed emission line fluxes. Theoretical emission measure distributions are calculated assuming that the radiation losses are balanced by the net conductive flux. We discuss how the area factor of the emitting regions as a function of temperature can be derived from a comparison between these emission measure distributions. It is found that the filling factor varies from ~ 0.2 in the mid transition region to ~ 1.0 in the inner corona. The sensitivity of these results to the adopted ion fractions, the iron abundance and other parameters is discussed. The area factors found are qualitatively similar to the observed structure of the solar atmosphere, and can be used to constrain two-component models of the chromosphere. Given further observations, the method could be applied to investigate the trends in filling factors with indicators of stellar activity.

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Onset of Shear Instability in Rotating Red Giants: Correlation with Onset of Mass Loss

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We incorporate into an evolutionary code a unified treatment of turbulent transport due to convective and shear instabilities in a rotating star. The effects of composition gradients are included in a consistent way. We use the code to follow the evolution of rotating stars from the pre-main sequence to near the tip of the red giant branch. We find that, at a certain stage in the red giant evolution of a $1M_{\odot}$ star, when the convectively unstable region occupies an extensive outer envelope, shear instability sets in a zone just below the H-burning shell. However, at a later time, shear instability also develops in a second (outer) region which lies between the H-burning shell and the convective envelope. The onset of the outer region of shear instability coincides closely in time with a well-defined feature of red giant evolution: the "bump" (so-called because of its effect on the luminosity function of clusters).

This evolutionary bump has recently been identified as a significant empirical marker among red giants: cool massive winds have been found to set in abruptly after the star evolves through the bump (Mullan and MacDonald 2003 ApJ 591 1203). The results we report in the present paper suggest that the onset of mass loss in red giants may be correlated with the onset of an outer region of shear instability inside the star. We offer some speculations concerning the possible physics of such a correlation.

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Reconstruction of Monthly and Yearly Group Sunspot Numbers from Sparse Daily Observations

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Some periods before 1820 are poorly covered by sunspot observations. In addition to apparent, long observational gaps, there are also periods when there are only few sparse daily sunspot observations during a long time. It is important to estimate the reliability of the monthly and yearly mean sunspot values obtained from such sparse daily data. Here we suggest a new method to estimate the reliability of individual monthly means. The method is based on comparing the actual sparse data (sample population) to the well-measured sunspot data in 1850-1996 (reference population), and assumes that the statistical properties of sunspot activity remain similar throughout the entire period. For each sample population we first found those months in the reference population that contain the same data set, and constructed the statistical distribution of the corresponding monthly means. The mean and standard error of this distribution represent the mean and uncertainty of a monthly mean sunspot number reconstructed from sparse daily observations. The simple arithmetic mean of daily values can be adequately applied for months which contain more than 4-5 evenly distributed daily observations. However, the reliability of monthly means for less covered months has to be estimated more carefully. Using the estimated, new monthly values, we have also calculated the weighted annual sunspot numbers.

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A Study of Grain Drift in C Stars.
Theoretical Modeling of Dust-Driven Winds in Carbon-Rich Pulsating Giant Stars

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Ph.D degree awarded: May 2003

A major fraction of stars will pass through a short period of dramatic events in their final evolutionary stage. Low- to intermediate-mass stars, studied here, are stripped of their outer parts in a slow massive wind. This mass loss reshapes both the star and the surrounding medium. The formation of the wind is a consequence of the non-linear interaction of a number of physical processes. Stellar pulsations and efficient dust formation are examples of such key processes. Time-dependent theoretical models, in combination with observations, are useful tools for understanding these winds.

The main object of this thesis has been the physical improvement of a theoretical wind model. Here the coupling between the dust and gas in the wind is studied in further detail, allowing drift. The methods that have been developed earlier to describe the micro-physical interaction are overviewed and summarized. Previously dust has often been assumed to move at the same velocity as gas. New time-dependent wind models are presented where grain drift has been treated self-consistently. Specifically, the coupling between dust and gas in the wind has been modeled more realistically, with descriptions of both the modified momentum and energy balances, and drift dependent dust formation. The results of these new "drift models" have been compared with the results of non-drift models.

A general result of the study is that the effects of drift are significant and difficult to predict if a simple analytical theory is used. It has been found that dust in drift models tends to accumulate in certain dense regions, an accumulation that was not possible without drift. Moreover the new models show an increased variability in the wind structure. The use of drift in dust formation tends to markedly increase the produced dust. Some sets of model parameters lead to a wind without including drift, but a corresponding wind does not form when drift is included – and vice versa. The effects of drift are important and can probably not be ignored in realistic models.

Thesis-related publications: A&A 2003, 398, 253; A&A 2003, 404, 789; A&A 2003, submitted

On-line version of the thesis can be found on: http://publications.uu.se/theses/abstract.xsql?dbid=3397

Upcoming Meeting

SAAS Fee Winter School (First Announcement)

The Sun, Solar Analogs, and the Climate

15 - 20 March 2004

Davos, Switzerland

The Swiss Society of Astrophysics & Astronomy (SSAA) is now organizing its 34th Advanced Course in Astronomy and Astrophysics. This winter school will be held in Davos, Switzerland from March 15 to 20, 2004. The subject of the course is: THE SUN, SOLAR ANALOGS AND THE CLIMATE. The course will address the subject of the solar variability and its interaction with the terrestrial climate. In these times of concern about global warming, it is important to understand the solar variability and its interaction with the atmosphere, in order to be able to distinguish between the solar and anthropogenic contributions to the rising temperatures in the last century. One third of the course will be devoted to the observed variability of the Sun, its theoretical origin and the present understanding of the variability. The second third of the course will address the Earth'ss climate and how solar variability affects it. Finally, the last third will discuss the variability of solar analog stars. This helps to better understand the solar cycle and to estimate how large the solar variations could be on longer time scales, and consequently, which effect the long term solar variability has on the Earth's climate.

The lectures will be given in English by three experts, each covering one of the three topics:
Mike Lockwood (Solar variability)
Mark Giampapa (Stellar variability)
Joanna Haigh (Sun-Earth relationship)

The course is intended mainly for post-graduate astronomers and physicists who wish to broaden their knowledge in the field. More information on the course program, general information and registration is available on the following web-site: http://www.pmodwrc.ch .

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Openings for Ph.D. Students

Ph.D. Student Openings and Research Assistantships
Astronomy Group
University of Texas at Arlington

The Astronomy Group at the Department of Physics, University of Texas at Arlington (Dallas-Fort Worth Metroplex) has one or more openings for Ph.D. students. The Astronomy Group has a broad range of research interests, including solar and stellar physics, magnetohydrodynamics, extra-solar planets, orbital stability analysis and chaos, stellar habitable zones and astrobiology. Research assistantships are available.

Applicants should indicate their interest directly to

Prof. Manfred Cuntz
Department of Physics
Science Hall
University of Texas at Arlington
Arlington, TX 76019-0059

Email: cuntz@uta.edu

and should arrange for two letters of recommendation. Offer available until position(s) are filled.

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 .`

*** Please send abstracts in the body of the message and *not* as attachments.***