COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Spectral Indications of Density Variability in the Corona of AD Leonis

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Direct comparison of high-resolution X-ray spectra of the active dMe star AD Leo, observed three times with *Chandra*, shows variability of key density-sensitive lines, possibly due to flaring activity. In particular, a significant long-duration enhancement of the coronal density is indicated by the Ne IX and Si XIII He-like triplets, and possibly also by density-sensitive Fe XXI line ratios.

To appear in ApJ Letters

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The Young Active Binary Star EK Draconis

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EK Dra (HD 129333) is a young, active, nearby star that is orbited by a low mass companion. By combining new speckle observations with old and new radial velocity measurements we find that the orbit is highly eccentric with $e = 0.82 \pm 0.03$, and we derive the true masses of both components. The masses are $0.9 \pm 0.1\,M_\odot$ and $0.5 \pm 0.1\,M_\odot$, for the primary and secondary, respectively. From high resolution spectra we derive a new $T_{\rm eff}$ of 5700 ± 70 K and a $\log g$ of 4.37 ± 0.10, which is different to previous estimates. However, the new spectroscopic distance differs by only 5.8% to the distance derived by parallax measurement by the *Hipparcos* satellite and thus the stellar parameters

are presumably more realistic than older determinations. We derive a somewhat higher value for the metallicity of $[Fe/H] = -0.16 \pm 0.07$. EK Dra turns out to be one of the few nearby young stars that will evolve similarly to the Sun. The precise radial velocity measurements taken in the course of this program also allow us to shed more light on the activity of this star. In 2001 and 2002 we find radial velocity variation with a period of 2.767 ± 0.005 days which we interpret as the rotation period. This signal vanishes in 2003. However the signal can be recovered if only the spectra in which the photospheric lines are asymmetric are used. On the other hand, we do not find a close correlation between the asymmetry of photospheric lines and the radial velocity.

Accepted by A&A

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For preprints via ftp or WWW: http://arXiv.org/pdf/astro-ph/0501608

Detection of Red Line Asymmetries in LHS 2034

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We report very pronounced line asymmetries during a long duration flare on the dM6 star LHS 2034 (AZ Cnc). While all lines of the Balmer series and all strong He I lines show these asymmetries, the metal lines do not. This can be explained with the help of PHOENIX model chromospheres considering the formation depth of the involved lines. Moreover, the asymmetries persist over about one hour changing shape and amplitude. Fitting the asymmetries with an additional broad Gaussian component leads us to the scenario of a series of downward propagating condensations that decelerates due to the higher densities of the lower chromosphere. In addition, similar but weaker line asymmetries were found in LHS 2397a.

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Infrared Photometry of the Carbon Star RW LMi and an Axisymmetric Model for Its Dust Envelope

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We obtained the JHKLM infrared photometric data for the carbon star RW LMi (= CIT 6 = IRC+30219 = AFGL 1403) using the 1.25-m telescope of the Crimean Laboratory of the Sternberg Astronomical Institute in 1997-2003. The observational data show that, since the middle of 1998, periodic variations of the flux have occurred against the background of a rising mean flux level, which increases by nearly a factor of three in the J-waveband in 1998-2003. The average HK fluxes were also higher in 1998-2003 than in 1986-1998, while no such increase in the 3.5 and $5-\mu m$ fluxes was observed (in fact, the fluxes in these wavebands even decreased slightly). We suggest that these flux variations were due to a decrease in the optical depth of the circumstellar dust envelope. We have developed an axisymmetric model for the dust envelope of the RW LMi with a density distribution typical for the superwind stage proposed by M.Meixner *et al.* (Astrophys. J. 2002, **571**, 936). We have used our JHKLM photometric data obtained in 1997-2003, supplemented by flux data at optical, mid-IR, and far-IR wavelengths. Along with spectrophotometric information, we have used the observations with a high angular resolution for comparisons with the model calculations. Optical images obtained with the Hubble Space Telescope and near-IR interferometric images obtained with the Keck-I telescope using an aperture mask are available for RW LMi. The radiative-transfer equation was solved using the 2-Dust code (T.Ueta and M.Meixner, Astrophys. J. 2003, **586**, 1338). In contrast to earlier spherically-symmetric models (M.B.Bogdanov and O.G.Taranova, Astron. Reports. 1999, **43**, 684) the axisymmetric model is able to reproduce the observed fluxes in all observed wavelength ranges, and provides a good agreement with the observational data. The estimated mass-loss rate is $\dot{M} = 1.2 \times 10^{-5}$ $M_\odot$ yr^{-1} . The computed brightness distribution of the envelope in the near-IR is in satisfactory agreement with the high angular resolution observations, while the optical size is considerably larger than is observed. (*continued* →)

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X-ray Properties of Active M Dwarfs as Observed by XMM-Newton

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We present a comparative study of X-ray emission from a sample of active M dwarfs with spectral types M3.5 - M4.5 using XMM-Newton observations of two single stars, AD Leonis and EV Lacertae, and two unresolved binary systems, AT Microscopii and EQ Pegasi. The light curves reveal frequent flaring during all four observations. We perform a uniform spectral analysis and determine plasma temperatures, abundances and emission measures in different states of activity. Applying multi-temperature models with variable abundances separately to data obtained with the EPIC and RGS detectors we are able to investigate the consistency of the results obtained by the different instruments onboard XMM-Newton. We find that the X-ray properties of the sample M dwarfs are very similar, with the coronal abundances of all sample stars following a trend of increasing abundance with increasing first ionization potential, the inverse FIP effect. The overall metallicities are below solar photospheric ones but appear consistent with the measured photospheric abundances of M dwarfs like these. A significant increase in the prominence of the hotter plasma components is observed during flares while the cool plasma component is only marginally affected by flaring, pointing to different coronal structures. AT Mic, probably a young pre-main-sequence system, has the highest X-ray luminosity and exhibits also the hottest corona. While results of EQ Peg and EV Lac are presented here for the first time, AT Mic and AD Leo have been investigated before with different analysis approaches, allowing a comparison of the results.

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Results of Magnetic Field Measurements on Four Yellow Supergiants. I.

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Results of high precision measurements of the net longitudinal component of magnetic field strength B_e performed during 31 nights for four yellow supergiants - β Aqr (G0 Ib), α Aqr (G2 Ib), ϵ Gem (G8 Ib), ϵ Peg (K2 Ib) - are reported. The best accuracy, $\sigma = 0.8$ G, was achieved for ϵ Peg. In order to test the real accuracy of the measurements, Monte Carlo simulations of the experimental errors are used. The discrepancy between observational errors and standard deviations from Monte Carlo simulations created using generator of the normal distribution numbers is about 3.2%. For ϵ Gem and ϵ Peg the presence of general magnetic field are detected. During five (out of 14 nights, in total) observational nights of ϵ Gem magnetic fields were: 11.1 $\pm$ 2.7 G, 9.8 $\pm$ 2.5 G, -10.5 $\pm$ 3.0 G, 38.1 $\pm$ 7.4 G, 5.3 $\pm$ 1.5 G. Two observational nights, out of 7, show the presence of magnetic field on ϵ Peg: -5.3 $\pm$ 0. 9 G, -2.7 $\pm$ 0.8 G.

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The Non-detection of Oscillations in Procyon by *MOST*: Is it Really a Surprise?

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We argue that the non-detection of oscillations in Procyon by the *MOST* satellite reported by Matthews et al. (2004) is fully consistent with published ground-based velocity observations of this star. We also examine the claims that the *MOST* observations represent the best photometric precision so far reported in the literature by about an order of magnitude and are the most sensitive data set for asteroseismology available for any star other than the Sun. These statements are not correct, with the most notable exceptions being observations of oscillations in α Cen A that are far superior. We further disagree that the hump of excess power seen repeatedly from velocity observations of Procyon can be explained as an artefact caused by gaps in the data. The *MOST* observations failed to reveal oscillations clearly because their noise level is too high, possibly from scattered Earthlight in the instrument. We did find an excess of strong peaks in the *MOST* amplitude spectrum that is inconsistent with a simple noise source such as granulation, and may perhaps indicate oscillations at roughly the expected level.

Accepted by A&A Letters

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For preprints via ftp or WWW: http://arXiv.org/abs/astro-ph/0501662

Flares Observed with *XMM-Newton* and the VLA

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We present lightcurves obtained in X-ray by the XMM-Newton EPIC cameras and simultaneous radio lightcurves obtained with the VLA for five active M-type flare stars. A number of flare events were observed, and by comparing radio with X-ray data, we consider various possible flare mechanisms. In cases where there seems to be a clear correlation between radio and X-ray activity, we use an energy budget argument to show that the heating which leads to the X-ray emission could be due to the same particles emitting in the radio. In cases where there is radio activity without corresponding X-ray activity, we argue that the radio emission is likely to arise from coherent processes involving comparatively few particles. In one case, we are able to show from polarization of the radio emission that this is almost certainly the case. Cases for which X-ray activity is seen without corresponding radio activity are more difficult to explain. We suggest that the heating particles may be accelerated to very high energy, and the resulting synchrotron radio emission may be beamed in directions other than the line of sight.

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Solar Abstracts

Flares Associated With the Abnormal Rotation Rates and Longitudinal Minimum Separation of the Leading and the Following Sunspots

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Using six years (1969-1974) data of sunspot groups from the white light pictures of the Kodaikanal Observatory, we compute rotation rates of the leading and the following sunspots and, rate of change of longitudinal separation during their life times. We find that : (i) the spots that are associated with the abnormal rotation rates (i.e, the rotation rates which are greater than 1σ from the mean rotation) which approach at the separation rate of $1 - 2\,deg/day$ also experience approaching minimum longitudinal separation ($\sim 6^o - 10^o$) of their foot points during the course of their evolution, (ii) such spots that have minimum separation eventually trigger the flares and, (iii) the events of abnormal rotation rates and the minimum approaching distances of the foot points on an average occur between $50 - 80\%$ of

the life spans indicating the depth of annihilation of magnetic energy probably below the surface. All these results support the conventional physical scenario of magnetic reconnection that may be responsible for triggering the flares.
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Overview of the Solar Activity During the Maximum Phase of Solar Cycle 23

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A brief description and final results of the flare index of solar activity for the maximum phase of the cycle 23 are given. The patterns of similar activity indices that arise under different physical conditions during the cycle 23 were compared with the flare index. The intermediate-term periodicities in the daily flare index data for the full disc and for the northern and the southern hemispheres of the Sun were calculated before by the authors using the Fourier transform, and it was found that 64, 125 days periodicities are in operation during the maximum phase of the solar cycle 23. In this paper we examined these periodicities in time domain by using the wavelet transform. The results of this transform show that during the maximum phase of the current solar cycle a very prominent multi–peaked structures exist in each solar hemisphere and the occurrence of flare index power is highly intermittent in time. Moreover it is found that the flare activity of the opposite hemispheres were not well time-synchronized during the maximum phase. The flare activity of the southern hemisphere was observed to be more dominant in determining the characteristics of the flare activity in the solar cycle 23..

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Intermittence of the Short-Term Periodicities of the Flare Index

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Intermittence of the short-term periodicities (25 − 35 days) of the flare index are investigated using the wavelet transform method for the full-disc and for the northern and the southern hemispheres of the Sun separately over the epoch since 1966 until 2002. The wavelet transform results show that occurence of periodicities of flare index power is highly intermittent in time. The period-averaged wavelet power of the flare index presents this fact very clearly displaying independence of flaring activity on the solar hemispheres in several time intervals over almost 4 solar cycles under study. Moreover correlations of the period-averaged wavelet power of the flare index for the separate hemispheres and for the full-disc reveal significantly stronger relation between the full-disc and the northern hemisphere than between the full-disc and the southern hemisphere while no significant correlations was found between the hemispheres one another.

Accepted by J. Adv. Space Res.

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Ph.D. Thesis Abstract

Modeling Solar Flare Hard X-ray Images and Spectra Observed with RHESSI

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Ph.D dissertation directed by: Gordon D. Holma

Ph.D degree awarded: January, 2005

Observations obtained with the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) of a flare on February 20, 2002 indicate a hard X-ray (HXR) coronal source at or near the top of a flare loop (called a HXR looptop source). The existence of the HXR looptop source suggests that magnetic reconnection, which is believed to power flares, occurs above the loop. In order to explain this HXR looptop source, I created a steady-state particle transport model, in which high-energy electrons are continuously injected at the top of a semicircular flare loop. Based on the simulation results, I find that the model predictions are consistent with the RHESSI observations in many respects, but the spectrum of the looptop source obtained from the model is steeper than that from the RHESSI data. This suggests that, instead of being accelerated above the loop as generally believed, the particles might be accelerated in the looptop itself.

RHESSI observations of three other homologous flares that occurred between April 14 and 16, 2002, provide strong evidence for the presence of a large-scale current sheet above a flare loop, which is the basis of standard flare models. The most convincing finding is the presence of the temperature distribution of a separate coronal source above the flare loops: the hotter part of the coronal source was located lower in altitude than the cooler part. Together with the fact that the hotter flare loops are higher than the cooler loops, the observations support the existence of a large-scale current sheet between the top of the flare loops and the coronal source above. Blob-like sources along a line above the loop in the decay phase of the April 15, 2002, flare, which are suggestive of magnetic islands initiated by the tearing-mode instability, and the observation of a cusp structure in microwaves, further support the presence of the current sheet.

The observations of the three homologous flares reveal two other features which are beyond the predictions of the standard flare models: the downward motion of flare loops in the early impulsive phase of each flare, and an initially stationary coronal source above the loops. These features are believed to be related to the formation and development of a current sheet. In particular, the downward loop motion seems to be a common phenomenon in flares, suggesting the necessity for modifications to the existing standard flare models.

Finally, thanks to the broad energy coverage of the RHESSI spectra, a low-energy cutoff of 28 (± 2) keV in the nonthermal electron distribution was determined for the April 15, 2002, flare. As a result, the energy carried by the nonthermal electrons is found to be comparable to the thermal energy of the flare, but one order of magnitude larger than the kinetic energy of the associated coronal mass ejection. The method used to deduce the electron low-energy cutoff will be useful in the analyses of similar events.

Thesis-related Publications: 2005, ApJ, Submitted; 2004, ApJ, 612, 546; 2003, ApJ, 596, L251; 2002, Solar Physics, 210, 245

Ph.D. Thesis Abstract

Solar and Stellar Coronal Structures: X-ray and EUV Observations, and Hydrodynamic Modeling

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This PhD thesis addresses the study of the coronal structures in various solar-like stars of different activity levels, and on the Sun. I have investigated the structure of stellar coronae through the analysis of high-resolution spectra and of spatially resolved solar observations; I have also used numerical loop models as diagnostic tools to gain insight into the physical processes ruling the outer stellar atmospheres and individual loops.

A large sample of *Chandra*-HETGS X-ray spectra of active stars has been analyzed in order to investigate how the properties of coronal structures depend on stellar parameters and activity level. The analysis of plasma density at different temperatures suggests the presence of different classes of emitting coronal structures in active stars ($L_{\mathrm{X}} > 10^{30}$ erg s^{-1}): a high pressure "hot" component with $T \sim$ 6–10 MK, plasma density n_{e} as high as $\sim 10^{12}$ cm^{-3}, and characteristic filling factors $\sim 10^{-4}$–10^{-1}; and a coexisting "cool" component characterized by plasma parameters closer to typical solar values, i.e. $T \sim$ 1–3 MK, $n_{\mathrm{e}} \sim 10^{10}$ cm^{-3}, and filling factors in the range 10^{-3}–1.

The high spectral resolution of *Chandra* spectra allowed us to carry out also a detailed analysis of possible scattering effects in strong resonance lines. Optical depth effects appear to be significant for a few stellar sources (II Peg and IM Peg): these findings represent the first clear evidence of resonant scattering in coronal X-ray emission lines, and allowed the first spectroscopic direct estimate of dimensions of the coronal structures in stars. Typical line-of-sight sizes of $\sim 10^{10}$ cm are found for coronal structures dominating the X-ray emission at temperatures of 3×10^{6} K, while sizes of $\sim 10^{8}$ cm are found for $T \sim 10^{7}$ K. These sizes are much smaller than (< 0.05 times) the stellar radius, and systematically higher than ($\sim$ 10 times) loop lengths expected for static models with constant cross-section and uniform heating (e.g., Rosner, Tucker & Vaiana, 1978).

The thermal distribution of the plasma in active stellar coronae is not reproduced by standard static models of magnetically confined loops. We find that also for some solar quiescent loops the derived thermal structure has characteristic features conflicting with static models expectations. We explored the stability and the distribution of emission measure vs. T in hydrodynamic loop models, depending on the spatial and temporal characteristics of the energy release. We have found that, for heating impulsively released close to the footpoints, long-lived loops can exist, and their thermal distribution is significantly different with respect to static models. The impulsive footpoint heating produces in the emission measure distribution of loop plasma the required changes to match the observed features of coronal thermal distributions.

In conclusion, this thesis draws a scenario of stellar coronal structures of very active stars characterized by more extreme features with respect to low-activity stars: significantly higher temperatures and densities, and steeper emission measure distributions are found for high activity levels. Nevertheless, coronal structures of stars of different activity levels also show similar features, indicating that the solar paradigm may still be valid to interpret stellar coronae.

Thesis-related Publications: ApJL, 609, 79; ApJ, 617, 508; ApJ, 622 in press

JOB OPENING

Two Four-Year Positions in Astrophysics
CIFIST Team
Observatoire de Paris

CIFIST (Cosmological Impact of the FIrst STars) is a Team, funded by the European Commission, through a Marie Curie Excellence Grant and hosted by Observatoire de Paris. We seek candidates for two four-year faculty positions, beginning in September 2005. One of the positions is intended for an early stage researcher, with less than four years experience in research after graduation(degree giving access to PhD studies), the other is intended for a more senior researcher. The main goal of the Team will be to study the properties of the first generations of stars in our Galaxy and also in external galaxies. We seek candidates with expertise in at least one of the following fields: a) observational spectroscopy, especially abundance analysis; b) theory of stellar atmospheres ; c) nucleosynthesis, especially r-process.

Applicants for the position of "early stage researcher" should be graduates in physics, astronomy, or related field. Applicants for the more senior position should hold a Ph.D. or equivalent in physics, astrophysics, or other related field. Send letter of application, publication list, vita, statement of research interests, to:

Piercarlo Bonifacio - Osservatorio Astronomico di Trieste - Via G.B. Tiepolo 11 - 34131 , Trieste, Italy.

It is preferable that the applications be sent also through e-mail: bonifaci@ts.astro.it Candidates should also arrange for three reference letters to be sent to P. Bonifacio (email: bonifaci@ts.astro.it).

Review of applications will begin after April 18th, 2005 and applications will continue to be accepted until the position is 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

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