COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Are Stellar Coronae Optically Thin in X-rays? A Systematic Investigation of Opacity Effects

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The relevance of resonant scattering in the solar corona has always been discussed controversially. Ratios of emission lines from identical ions but different oscillator strengths have been used in order to estimate damping of resonance lines due to possible resonant scattering, i.e., absorption by photo-excitation and re-emission out of the line of sight. The analysis of stellar spectra in analogy to previous works for the Sun is possible now with XMM-Newton and Chandra grating spectra and requires this issue to be considered again. In this work we present a sample of 44 X-ray spectra obtained for 26 stellar coronae with the RGS on board XMM-Newton and the LETGS and HETGS on board Chandra. We use ratios of the Fe XVII lines at 15.27 Å and 16.78 Å lines to the resonance line at 15.03 Å as well as the He-like f/r ratio of O VII and Ne IX to measure optical depth effects and compare them with ratios obtained from optically thin plasma atomic databases such as MEKAL, Chianti, and APEC. From the Fe XVII line ratios we find no convincing proof for resonance line scattering. Optical depths are basically identical for all kinds of stellar coronae and we conclude that identical optical depths are more probable when effects from resonant scattering are generally negligible. The 15.27/15.03 Å ratio shows a regular trend suggesting blending of the 15.27 Å line by a cooler Fe line, possibly Fe XVI. The He-like f/r ratios for O and Ne show no indication for significant damping of the resonance lines. We mainly attribute deviations from the atomic databases to still uncertain emissivities which do not agree well with laboratory measurements and which come out with differing results when accounting for one or the other side effect. We attribute the discrepancies in the solar data to geometrical effects from observing individual emitting regions in the solar corona but only overall emission for stellar coronae including photons eventually scattered into the line of sight.

Accepted by A&A

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Polar Fields for AB Dor

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Polar spots are often observed on rapidly-rotating cool stars, but the nature of the magnetic field in these spots is as yet unknown. While Zeeman-Doppler imaging can provide surface magnetic field maps over much of the observed stellar surface, the Zeeman signature is suppressed in the dark polar regions. We have determined the effect on the global coronal structure of three current models for this polar field: that it is composed (a) of unipolar field, (b) of bipolar regions or (c) of nested rings of opposite polarity. We take as an example the young, rapid rotator AB Dor($P_{\rm rot}$ = 0.514 days). By adding these model polar fields into the surface field maps determined from Zeeman-Doppler imaging, we have compared the resulting coronal structure with the observable properties of the corona - the magnitude and rotational modulation of the X-ray emission measure and the presence of slingshot prominences trapped in the corona around the Keplerian co-rotation radius. We find that only the presence of a unipolar spot has any significant effect on the overall coronal structure, forcing much of the polar field to be open.

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The Coronae of AR Lac

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We observed the coronally active eclipsing binary AR Lac with the High Energy Transmission Grating on Chandra for a total of 97 ks, spaced over five orbits, at quadratures and conjunctions. Contemporaneous and simultaneous EUV spectra and photometry were also obtained with the Extreme Ultraviolet Explorer. Significant variability in both X-ray and EUV fluxes were observed, dominated by at least one X-ray flare and one EUV flare. We saw no evidence of primary or secondary eclipses, but exposures at these phases were short and intrinsic variability compromised detection of any geometric modulation. X-ray flux modulation was largest at high temperature, indicative of flare heating of coronal plasma rather than changes in emitting volume or global emission measure. Analysis of spectral line widths interpreted in terms of Doppler broadening suggests that both binary stellar components are active. Based on line fluxes obtained from total integrated spectra, we have modeled the emission measure and abundance distributions. The EUV spectral line fluxes were particularly useful for constraining the parameters of the "cool" ($\leq 2 \times 10^6$ K) plasma. A strong maximum was found in the differential emission measure, characterized by two apparent peaks at $\log T = 6.9$ and 7.4, together with a weak but significant cooler maximum near $\log T = 6.2$, and a moderately strong hot tail from $\log T = 7.6 - 8.2$. Coronal abundances have a broad distribution and show no simple correlation with first ionization potential. While the resulting model spectrum generally agrees very well with the observed spectrum, there are some significant discrepancies, especially among the many Fe L-lines. Both the emission measure and abundance distributions are qualitatively similar to prior determinations from other X-ray and ultraviolet spectra, indicating some long-term stability in the overall coronal structure.

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The Identification of HCN and HNC in Carbon Stars: Model Atmospheres, Synthetic Spectra and Fits to Observations in the 2.7-4.0 micron Region.

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Model carbon star atmospheres and synthetic spectra have been calculated using the recent HCN/HNC vibration rotation linelist of Harris et al. (2002) ApJ, 578, 657. The calculations are repeated using only HCN lines and show that HNC has a significant effect upon the temperature, density and optical depth of a stellar atmosphere.

We fit synthetic spectra in the 2.7-4.0 micron region to observed ISO spectra of the carbon stars WZ Cas and TX Psc obtained by Aoki et al. (1998), A&A, 340, 222. These fits allow us to identify absorption by HNC in the spectrum of WZ Cas at 2.8-2.9 microns, and to determine new independent estimates of effective temperature and $\log(N_{\rm C}/N_{\rm O})$. The findings reported here indicate that absorption by both HCN *and* HNC is needed to fully explain the observed stellar spectra and represent the first identification of HNC in a star. Q branch absorption by the HCN $\Delta v_2 = 1$, $\Delta v_3 = 1$ and $\Delta v_1 = 1$, $\Delta v_2 = -1$ bands at 3.55 and 3.86 microns respectively, are identified in the spectrum of WZ Cas.

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Evidence for Coronal Activity Cycles on 61 Cygni A and B

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We investigate a four-and-one-half year time-series of ROSAT HRI pointed observations of 61 Cyg A and B and compare the X-ray light curves with the chromospheric Ca HK variability. The ROSAT sampling rate was two pointings per year and typical errors lie in the range of 5–10%. The chromospheric cycles are well-known for both stars from the Mt. Wilson Ca HK survey. Although the time basis of our ROSAT observations is shorter than the 7-and 12-year cycles of components A and B, respectively, we find the long-term trend of coronal activity in close correlation with the chromospheric activity during the observation period, between 1993 and 1998. The chromospheric activity increased through maximum activity down to a minimum for component A, and from maximum to minimum activity for component B. The same behaviour is observed for the X-ray light curves but with much higher amplitudes by factors 2.5–3. The remaining scatter observed around low-order regression curves of coronal activity is small. We conclude that both stars do show coronal cycles and that coronal cycles are the dominant source of variability for 61 Cygni.

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X-ray Rotational Modulation of a Supersaturated Star in IC 2391

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We present evidence of X-ray rotational modulation on VXR45, a young fast rotator star, member of IC It is a dG9 spectral type star whose rotational period and X-ray luminosity make it a supersaturated star. Our X-ray observation, made with EPIC/PN on XMM-Newton, covers about two photometric rotational periods. The detection of X-ray rotational modulation implies the presence of structural inhomogeneities. Possible interpretations are presented and discussed.

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Three Years in the Coronal Life of AB Dor I. Plasma Emission Measure Distributions and Abundances at Different Activity Levels.

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The young active star AB Dor (K1 IV-V) has been observed 16 times in the last three years with the XMM-Newton and Chandra observatories, totalling 650 ks of high-resolution X-ray spectra. The XMM/RGS observations with the highest and lowest average emission levels have been selected to study the coronal properties of AB Dor in two different activity levels. We compare the results based on the XMM data with those obtained from a higher resolution Chandra/HETG spectrum, using the same line-based analysis technique. We have reconstructed the plasma Emission Measure Distribution vs. temperature (EMD) in the range log T(K)$\sim$6.1–7.6, and we have determined the coronal abundances of AB Dor, obtaining consistent results between the two instruments. The overall shape of the EMD is also consistent with the one previously inferred from EUVE data. The EMD shows a steep increase up to the peak at log T(K)$\sim$6.9 and a substantial amount of plasma in the range log T(K)$\sim$6.9–7.3. The coronal abundances show a clear trend of increasing depletion with respect to solar photospheric values, for elements with increasing First Ionization Potential (FIP), down to the Fe value ([Fe/H] = –0.57), followed by a more gradual recovery of the photospheric values for elements with higher FIP. He-like triplets and Fe XXI and Fe XXII lines ratios indicate electron densities log $n_{\rm e} \sim 10.8\,{\rm cm}^{-3}$ at log T(K)$\sim$ 6.3 and log $n_{\rm e} \sim 12.5\,{\rm cm}^{-3}$ at log T(K)$\sim$7, implying plasma pressures steeply increasing with temperature. These results are interpreted in the framework of a corona composed of different families of magnetic loop structures, shorter than the stellar radius and in isobaric conditions, having pressures increasing with the maximum plasma temperature, and which occupy a small fraction ($f \sim 10^{-4}$–10^{-6}) of the stellar surface.

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Late B-type Stars and Their Candidate Companions Resolved with Chandra

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We present the first results from a series of Chandra observations carried out with the aim to examine the origin of X-ray emission in main-sequence late B-type stars. We use high spatial resolution X-ray observations to enlighten the prevalent speculation that previously unknown late-type or low-mass companion stars are the sites of the X-ray emission, instead of the B-type primaries. Here we present the results for HD1685, HD113703, HD123445, HD133880, and HD169978. Adaptive optics observations have recently revealed at least one faint object near each of these B-type stars (at separation of $1-6''$). Four of the new infrared objects show infrared colors and magnitudes typical for low-mass pre-main sequence stars, and are likely true companions to the 10-50 Myr old B-type stars. These multiple systems are now resolved for the first time in X-ray light.

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Solar Abstracts

Dynamics of the Solar Chromosphere IV. Evidence for Atmospheric Gravity Waves from TRACE

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We study the low-frequency brightness modulation of internetwork regions in the low solar chromosphere using simultaneous ultraviolet and white-light image sequences from the *Transition Region and Coronal Explorer* (TRACE). The ultraviolet sequences exhibit a slowly varying brightness pattern in internetwork regions on which the more familiar acoustic three-minute oscillation is superimposed, with about half of the peak brightness reached in internetwork grains contributed by the low-frequency background. We address the nature of the latter, applying two-dimensional Fourier filtering to isolate it from the acoustic modulation. Spatio-temporal comparisons and selective time-delay scatter correlations between the ultraviolet and white-light low-frequency sequences establish that reversed granulation constitutes at most a minor part of the ultraviolet background. Fourier analysis shows that the meso-scale contribution dominates and consists of atmospheric gravity waves.

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Families of Fragmenting Granules and Their Relation to Meso– and Supergranular Flow Fields

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3D analysis (x, y, t) of the granular intensity field (11–hour time sequence from the Swedish Vacuum Solar Telescope on La Palma, Canary Islands), demonstrates that a significant fraction of the granules in the photosphere are organized in the form of "Trees of Fragmenting Granules" (TFGs). A TFG consists of a family of repeatedly splitting granules, originating from a single granule at its beginning. A striking result is that TFGs can live much longer (up to 8 h) than individual granules (10 min). We find that 62 % of the area covered by granules belongs to TFGs of a lifetime $>$ 1.5 h. When averaged in time, such long–lived TFGs correspond to coherent diverging flows which may be identified as mesogranules. We also find a correlation between the network and the spatial distribution of TFGs.

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Job Opening

Research Position
High-Energy Astrophysics
University of Geneva (Switz.)

The University of Geneva is opening a position of "Maitre d'enseignement et de recherche" in its Department of Astronomy (Geneva Observatory).

The candidate is expected to contribute to the high energy astrophysics research of the department and in particular to the scientific exploitation of the INTEGRAL data. The Geneva Observatory is host to the INTEGRAL Science Data Centre (ISDC) where the successfull candidate will work. The ISDC is in charge of receiving, processing, analysing, distributing and archiving the INTEGRAL data. Beside its service activities the centre actively contributes to research in the fields of active galactic nuclei, X-ray binary systems and nucleo-synthesis. The candidate is expected to participate in these research efforts.

The candidate is also expected to contribute to the running of the centre. The duties will include an active participation in the leadership of the centre both in its administration and in its project and science activities. The successfull candidate will have to represent the ISDC in national and international committees.

The successfull candidate will also contribute to the teaching of astrophysics in Geneva through specialised courses and/or seminars. The candidate will have the possibility to lead Diploma and PhD theses in collaboration with a professor of the Observatory.

Candidates should have a PhD in physics or astronomy and a proven track of high quality research. A good knowledge of large astronomical data analysis systems is mandatory. Some previous experience in the development and/or operation of a science data centre would be an asset as would be a sound knowledge of the INTEGRAL instruments and mission.

Candidates should send 5 copies of: their curriculum vitae, list of publications, statement of interest and research plan and one certified copy of the highest degree to Prof. M. Mayor, Observatoire de Geneve, 51, ch. des Maillettes, CH-1290 SAUVERNY, before September 10, 2003.

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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