// COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Metallicity Measurements Using Atomic Lines in M and K Dwarf Stars

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We report the first survey of chemical abundances in M and K dwarf stars using atomic absorption lines in high resolution spectra. We have measured Fe and Ti abundances in 35 M and K dwarf stars using equivalent widths measured from $\lambda/\Delta\lambda \approx 33\,000$ spectra. Our analysis takes advantage of recent improvements in model atmospheres of low-temperature dwarf stars. The stars have temperatures between 3300 and 4700 K, with most cooler than 4100 K. They cover an iron abundance range of $-2.44 <$ [Fe/H] $< +0.16$. Our measurements show [Ti/Fe] decreasing with increasing [Fe/H], a trend similar to that measured for warmer stars where abundance analysis techniques have been tested more thoroughly. This study is a step toward the observational calibration of procedures to estimate the metallicity of low-mass dwarf stars using photometric and low-resolution spectral indices.

Accepted by MNRAS

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High Resolution, Long – Slit Spectroscopy of VY CMa: The Evidence for Localized High Mass Loss Events

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High spatial and spectral resolution spectroscopy of the OH/IR supergiant VY CMa and its circumstellar ejecta reveals evidence for high mass loss events from localized regions on the star occurring over the past 1000 years. The reflected absorption lines and the extremely strong K I emission lines show a complex pattern of velocities in the ejecta. We show that the large, dusty NW arc, expanding at ≈ 50 km s^{-1} with respect to the embedded star, is kinematically distinct from the surrounding nebulosity and was ejected about 400 years ago. Other large, more filamentary loops were probably expelled as much as 800 to 1000 years ago while knots and small arcs close to the star resulted from more recent events 100 to 200 years ago. *The more diffuse, uniformly distributed gas and dust is surprisingly stationary* *with little or no velocity relative to the star.* This is not what we would expect for the circumstellar ma terial from an evolved red supergiant with a long history of mass loss. We therefore suggest that the high mass loss rate for VY CMa is a measure of the mass carried out by these specific ejections accompanied by streams or flows of gas through low density regions in the dust envelope. VY CMa may thus be our most extreme example of stellar activity, but our results also bring into question the evolutionary state of this famous star. In a separate Appendix, we discuss the origin of the very strong K I and other rare emission lines in its spectrum.

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HD 166181 = V815 Herculis, A Single-Lined Spectroscopic Multiple System

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We have obtained extensive spectroscopic and velocity spectrometer observations of HD 166181, a previously known single-lined spectroscopic binary. Our improved orbit for the G6 V primary has a period of 1.8098343 days and is circular. Although the lines of additional components have not been detected, radial-velocity measurements confirm that the system has additional velocity variations with a period of 2092 days or 5.73 years. This long-period orbit has an eccentricity of 0.76. An analysis of the *Hipparcos* observations produces a well-determined astrometric orbit for the long-period system that has an inclination of 78 degrees. Mass estimates of the components in this zero-age main-sequence multiple system indicate that the unseen secondary in the 5.73-year orbit may also be a binary. Thus, HD 166181 is at least a triple system and possibly quadruple.

Accepted by AJ

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Relationship Between X-ray and Ultraviolet Emission of Flares from dMe Stars Observed by XMM-Newton

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We present simultaneous ultraviolet and X-ray observations of the dMe-type flaring stars AT Mic, AU Mic, EV Lac, UV Cet and YZ CMi obtained with the XMM-Newton observatory. During 40 hours of simultaneous observation we identify 13 flares which occurred in both wave bands. For the first time, a correlation between X-ray and ultraviolet flux for stellar flares has been observed. We find power-law relationships between these two wavelength bands for the flare luminosity increase, as well as for flare energies, with power-law exponents between 1 and 2. We also observe a correlation between the ultraviolet flare energy and the X-ray luminosity increase, which is in agreement with the Neupert effect and demonstrates that chromospheric evaporation is taking place.

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VLA Observations of ζ Aurigae: Confirmation of the Slow Acceleration Wind Density Structure

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Studies of the winds from single K and early M evolved stars indicate that these flows typically reach a significant fraction of their terminal velocity within the first couple of stellar radii. The most detailed spatially-resolved information of the extended atmospheres of these spectral types comes from the ζ Aur eclipsing binaries. However, the wind acceleration inferred for the evolved primaries in these systems appears significantly slower than for stars of similar spectral type. Since there are no successful theories for mass loss from K and early M evolved stars, it is important to place strong empirical constraints on potential models, and determine whether this difference in acceleration is real or an artifact of the analyses. We have undertaken a radio continuum monitoring study of ζ Aurigae (K4 Ib + B5 V) using the Very Large Array to test the wind density model of Baade et al. (1996) which is based on *HST*/GHRS ultraviolet spectra. ζ Aurigae was monitored at centimeter wavelengths over a complete orbital cycle and flux variations during the orbit are found to be of similar magnitude to variations at similar orbital phases in the adjacent orbit. During eclipse the flux does not decrease showing that the radio emission originates from a volume substantially larger than $R_K^3 \sim (150R_\odot)^3$ surrounding the B star. Using the 1-D density model of the K4 Ib primary's wind derived from *HST* spectral line profile modeling, and electron temperature estimates from previous optical and new *HST* studies, we find that the predicted radio fluxes are consistent with those observed. 3-D hydrodynamic simulations indicate that the accretion flow perturbations near the B star do not contribute significantly to the total radio flux from the system, consistent with the radio eclipse observations. Our radio observations confirm the slow wind acceleration for the evolved K4 Ib component. ζ Aurigae's velocity structure does not appear to be typical of single stars with similar spectral types. This highlights the need for more comprehensive multi-wavelength studies for both single stars, which have been sadly neglected, and other ζ Aur systems to determine if its wind properties are typical.

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Starspots, Activity Cycles, and Differential Rotation on Cool Stars

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We present the first results in searching for stellar cycles by the analysis of the stellar spottedness with the algorithm developed in CrAO. For more than 35 red spotted stars, we find 10 targets which demonstrate cyclic variations of average latitudes and total areas of starspots. Activity cycles detected by this method have a typical cycle length about $4 - 15$ years which are analogous to the 11-year solar Schwabe cycle. Most of the program stars demonstrate a rough analogue of the solar butterfly diagram. They show a tendency of an average starspot latitude lowering when the total spot area grows. At the same time these stars show variations of stellar photometric period (which is traced by starspots) with the starspots latitudinal drift analogously to the solar differential rotation effect. We suspected that the starspots latitudinal drift rate and the differential rotation gradient depend on the stellar spectral type.

Accepted by Solar Physics

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Anti-Solar Differential Rotation

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The differential rotation of anti-solar type detected by observations for several stars may result from a fast meridional

flow. The sufficiently intensive meridional circulation may be caused by large-scale thermal inhomogeneities or, perhaps, by tidal forcing from a companion star. First results of simulations of the anti-solar rotation of a giant star with magnetically induced thermal inhomogeneities are presented. Perspectives for observational check of the theory are discussed.

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X-rays from Hybrid Stars

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Late-type giants and supergiants of the "hybrid chromosphere" class display signatures of cool ($T < 2 \times 10^4$ K) winds together with hot emission lines from species like C IV ($T \sim 10^5$ K). A survey of such stars by Reimers et al. using the *Roentgensatellit* (*ROSAT*) reported numerous X-ray detections ($T \sim 10^6$ K), strengthening the—then heretical—idea that hot coronae and cool winds can coexist in luminous giants. However, several of the candidate sources were offset from the predicted stellar coordinates, calling into question the identifications. In an effort to secure better knowledge of the X-ray luminosities of the hybrids, the *ROSAT* fields from the Reimers et al. survey were reexamined, exploiting the U.S. Naval Observatory A2 astrometric catalog to register the pointings to few-arcsecond accuracy. On the basis of positional mismatches, at least two of the previously reported detections of key hybrid stars—γ Draconis (K5 III) and β Aquarii (G0 Ib)—must be rejected. The new X-ray upper limits for these stars, combined with the remaining candidate detections (and nondetections) from the original survey, place the hybrids into the same "X-ray deficient" category as the "noncoronal" red giants like Arcturus (α Boötis: K1.5 III) and Aldebaran (α Tauri: K5 III). A few of the hybrid X-ray sources are exceptional, however. The archetype α Trianguli Australis (K2 II-III), in particular, is securely detected in terms of positional coincidence, but its anomalous, contradictory coronal properties suggest that an unseen companion—a young hyperactive G dwarf—might dominate the X-ray emission.

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Solar Abstracts

Did Open Solar Magnetic Field Increase During the Last 100 Years: A Reanalysis of Geomagnetic Activity

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Long-term geomagnetic activity presented by the aa index has been used to show that the heliospheric magnetic field has more than doubled during the last 100 years. However, serious concern has been raised on the long-term consistency of the aa index and on the centennial rise of the solar magnetic field. Here we reanalyze geomagnetic activity during the last 100 years by calculating the recently suggested IHV (Inter-Hour Variability) index as a measure of local geomagnetic activity for seven stations. We find that local geomagnetic activity at all stations follows the same qualitative long-term pattern: an increase from early 1900s to 1960, a dramatic dropout in 1960s and a (mostly weaker) increase thereafter. Moreover, at all stations, the activity at the end of the 20th century has a higher average level than at the beginning of the century. This agrees with the result based on the aa index that global geomagnetic activity, and thereby, the open solar magnetic field has indeed increased during the last 100 years. However, quantitatively, the estimated centennial increase varies greatly from one station to another. We find that the relative increase is higher at the high-latitude stations and lower at the low and mid-latitude stations. These differences may indicate that the fraction of solar wind disturbances leading to only moderate geomagnetic activity has increased during the studied

time interval. We also show that the IHV index needs to be corrected for the long-term change of the daily curve, and calculate the corrected IHV values. Most dramatically, we find the centennial increase in global geomagnetic activity was considerably smaller, only about one half of that depicted by the aa index.

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Systematically Asymmetric Heliospheric Magnetic Field: Evidence for a Quadrupole Mode and Non-axisymmetry with Polarity Flip-flops

Kalevi Mursula[1], and Teemu Hiltula[1]

[1] Department of Physical Sciences, University of Oulu, Finland Recent studies of the heliospheric magnetic field (HMF) have detected interesting, systematic hemispherical and longitudinal asymmetries which have a profound significance for the understanding of solar magnetic fields. The in situ HMF measurements since 1960s show that the heliospheric current sheet (HCS) is systematically shifted (coned) southward during solar minimum times, leading to the concept of a bashful ballerina. While temporary shifts can be considerably larger, the average HCS shift (coning) angle is a few degrees, less than the 7.2° tilt of the solar rotation axis. Recent solar observations during the last two solar cycles verify these results and show that the magnetic areas in the northern solar hemisphere are larger and their intensity weaker than in the south during long intervals in the late declining to minimum phase. The multipole expansion reveals a strong quadrupole term which is oppositely directed to the dipole term. These results imply that the Sun has a symmetric quadrupole S0 dynamo mode that oscillates in phase with the dominant dipole A0 mode. Moreover, the heliospheric magnetic field has a strong tendency to produce solar tilts that are roughly opposite in longitudinal phase. This implies is a systematic longitudinal asymmetry and leads to a "flip-flop" type behaviour in the dominant HMF sector whose period is about 3.2 years. This agrees very well with the similar flip-flop period found recently in sunspots, as well as with the observed ratio of three between the activity cycle period and the flip-flop period of sun-like stars. Accordingly, these results require that the solar dynamo includes three modes, A0, S0 and a non-axisymmetric mode. Obviously, these results have a great impact on solar modelling.

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On the Generation, Propagation, and Reflection of Alfvén Waves from the Solar Photosphere to the Distant Heliosphere

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We present a comprehensive model of the global properties of Alfvén waves in the solar atmosphere and the fast solar wind. Linear non-WKB wave transport equations are solved from the photosphere to a distance past the orbit of the Earth, and for wave periods ranging from 3 seconds to 3 days. We derive a radially varying power spectrum of kinetic and magnetic energy fluctuations for waves propagating in both directions along a superradially expanding magnetic flux tube. This work differs from previous models in three major ways. (1) In the chromosphere and low corona, the successive merging of flux tubes on granular and supergranular scales is described using a two-dimensional magnetostatic model of a network element. Below a critical flux-tube merging height the waves are modeled as thin-tube kink modes, and we assume that all of the kink-mode wave energy is transformed into volume-filling Alfvén waves above the merging height. (2) The frequency power spectrum of horizontal motions is specified only at the photosphere, based on prior analyses of G-band bright point kinematics. Everywhere else in the model the amplitudes of outward and inward propagating waves are computed with no free parameters. We find that the wave amplitudes in the corona agree well with off-limb nonthermal line-width constraints. (3) Nonlinear turbulent damping is applied to the results of the linear model using a phenomenological energy loss term. A single choice for the normalization of the turbulent outer-scale length produces both the right amount of damping at large distances (to agree with in situ measurements) and the right amount of heating in the extended corona (to agree with empirically constrained solar wind acceleration models). In the corona, the modeled heating rate differs by more than an order of magnitude from

a rate based on isotropic Kolmogorov turbulence.

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For preprints via ftp or WWW: http://arXiv.org/abs/astro-ph/0410639

Survey on Solar X-ray Flares and Associated Coherent Radio Emissions

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The radio emission during 201 X-ray selected solar flares was surveyed from 100 MHz to 4 GHz with the Phoenix-2 spectrometer of ETH Zurich. The selection includes all RHESSI flares larger than C5.0 jointly observed from launch until June 30, 2003. Detailed association rates of radio emission during X-ray flares are reported. In the decimeter wavelength range, type III bursts and the genuinely decimetric emissions (pulsations, continua, and narrowband spikes) were found equally frequently. Both occur predominantly in the peak phase of hard X-ray (HXR) emission, but are less in tune with HXRs than the high-frequency continuum exceeding 4 GHz, attributed to gyrosynchrotron radiation. In 10% of the HXR flares, an intense radiation of the above genuine decimetric types followed in the decay phase or later. Classic meter-wave type III bursts are associated in 33% of all HXR flares, but only in 4% they are the exclusive radio emission. Noise storms were the only radio emission in 5% of the HXR flares, some of them with extended duration. Despite the spatial association (same active region), the noise storm variations are found to be only loosely correlated in time with the X-ray flux. In a surprising 17% of the HXR flares, no coherent radio emission was found in the extremely broad band surveyed. The association but loose correlation between HXR and coherent radio emission is interpreted by multiple reconnection sites connected by common field lines.

Accepted by Solar Physics

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Job Openings

Ph.D. Studentships (Two Openings)
Substellar Mass Objects
Max-Planck-Institute for Astronomy
Heidelberg, Germany

The Max-Planck-Institute for Astronomy is looking to fill two PhD studentships on the topic *Properties and formation of substellar mass objects*. The positions are available as part of a new Emmy-Noether research group under Dr. Coryn Bailer-Jones. This group will focus on observational tests of the formation of brown dwarfs and giant exosolar planets as well as the study of their cool atmospheres.

The two PhD projects available are:

1. Brown dwarf origins: Deep photometric surveys to search for brown dwarfs and free-floating planets.
2. Brown dwarf atmospheres: Study of the atmospheres of ultra cool dwarfs using, e.g., photometric and spectroscopic monitoring.

The group has access to the world's most advanced observational facilities, including the Very Large Telescope (VLT) in Chile and the Calar Alto Observatory in Spain. Travel to the observatories is an essential part of the work, which includes observing, the reduction and analysis of data and their scientific interpretation. The group will also develop and apply data mining techniques to large databases for studying the formation and evolution of stellar clusters. The group has access to data from the Sloan Digital Sky Survey, and involvement with the future satellite mission Gaia will be possible. The opportunity to participate in international conferences and summer schools will be provided.

The positions are available on the German BAT federal public service scale (BAT IIa/2) for up to three years starting in early 2005. Completion of an undergraduate degree in Physics or closely related subject is a prerequisite. Some programming experience is also required. Applicants should send a CV giving details of their education and relevant experience, including degree courses and grades obtained. Applications may be sent by mail or email (as PS or PDF files) in English or German to

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Applicants should also arrange for at least one (but preferably two) letters of recommendation to be sent by mail to the above address. The deadline for the receipt of applications and letters is 10 December 2004, although applications will be considered until the positions are filled. Informal enquiries are welcome. For more information visit `http://www.mpia-hd.mpg.de/`

The Max Planck Society is an equal opportunity employer. Applications from women, disabled people and minority groups are particularly welcome.

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.***