COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

The Metal-Rich Nature of Stars with Planets

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With the goal of confirming the metallicity "excess" present in stars with planetary-mass companions, we present in this paper a high-precision spectroscopic study of a sample of dwarfs included in the CORALIE extrasolar planet survey. The targets were chosen according to the basic criteria that 1) they formed part of a limited volume and 2) they did not present the signature of a planetary host companion. A few stars with planets were also observed and analysed; namely, HD 6434, HD 13445 (Gl 86), HD 16141, HD 17051 (ι Hor), HD 19994, HD 22049 (ϵ Eri), HD 28185, HD 38529, HD 52265, HD 190228, HD 210277 and HD 217107. For some of these objects there had been no previous spectroscopic studies.
The spectroscopic analysis was done using the same technique as in previous work on the metallicity of stars with planets, thereby permitting a direct comparison of the results. The work described in this paper thus represents the first uniform and unbiased comparison between stars with and without planetary-mass companions in a volume-limited sample. The results show that 1) stars with planets are significantly metal-rich, and 2) that the source of the metallicity is most probably "primordial". The results presented here may impose serious constraints on planetary system formation and evolution models.

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New Analyses of Star-to-Star Abundance Variations Among Bright Giants in the Mildly Metal-Poor Globular Cluster M5

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We present a chemical composition analysis of 36 giant stars in the mildly metal-poor globular cluster M5 (NGC 5904). The analysis makes use of high resolution data acquired at the Keck I telescope as well as a re-analysis of high resolution spectra acquired for an earlier study at Lick Observatory. We employed two analysis techniques: one, adopting standard spectroscopic constraints, and two, adopting an analysis consistent with the non-LTE precepts as recently described by Thevenin & Idiart. The abundance ratios we derive for magnesium, silicon, calcium, scandium, titanium, vanadium, nickel, barium and europium in M5 show no significant abundance variations and the ratios are comparable to those of halo field stars. However, large variations are seen in the abundances of oxygen, sodium and aluminum, the elements that are sensitive to proton-capture nucleosynthesis. In comparing the abundances of M5 and M4 (NGC 6121), another mildly metal-poor globular cluster, we find that silicon, aluminum, barium and lanthanum are overabundant in M4 with respect to what is seen in M5, confirming and expanding the results of previous studies. In comparing the abundances between these two clusters and others having comparable metallicities, we find that the anti-correlations observed in M5 are similar to those found in more metal-poor clusters, M3, M10 and M13, whereas the behavior in M4 is more like that of the more metal-rich globular cluster M71. We conclude that among stars in Galactic globular clusters, there is no definitive "single" value of [el/Fe] at a given [Fe/H] for at least some α-capture, odd-Z and slow neutron-capture process elements, in this case, silicon, aluminum, barium and lanthanum.

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For preprints via ftp or WWW: http://arXiv.org/abs/astro-ph/0106249

Infrared Optical Properties of Spinels: A Study of the Carrier of the 13, 17 and 32 μm Emission Features Observed in ISO-SWS Spectra of Oxygen-rich AGB Stars

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In a previous paper, we have proposed magnesium aluminium spinel to be the carrier of the 13 and 17 μm band features observed in the ISO spectra of some red giants. The IR optical properties of spinel strongly depend on its chemistry and its internal structure. To study the dependence of spinel's IR-spectra on its aluminium content, we have synthesized a number of crystals with different Al/Mg-ratios. Additionally, we performed an annealing experiment to investigate the phase transition between ordered and partially disordered spinel taking place at about 1200 K. We derived sets of optical constants of our natural, annealed and synthetic spinels in order to calculate the absorption efficiencies of small (sub-μm-sized) spherical particles. Thereby, it turned out that natural as well as near-stoichiometric synthetic spinel can indeed be considered as a suitable candidate for the carrier of the 13 μm feature observed in the spectra of some oxygen rich circumstellar shells. To illustrate this, we reinvestigated the mean profile of the residual dust emission in the 12–18 μm wavelength range (i. e., in the so-called trough region between the two silicate bands). The reality of the emission feature at 16.8 μm is confirmed by our new investigation. We demonstrated that it is not an instrumental artifact since it is not present in ISO spectra of K-stars. In the course of our laboratory work, we found a third prominent emissivity maximum of spinel at 32 μm. This feature could also be detected in the spectra of the brightest 13 μm band emission sources; we derived its mean band profile, too. The new sets of optical constants here presented have been made available for public access in the electronic database `http://www.astro.uni-jena.de.`

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X-Ray Spectroscopy of II Pegasi: Coronal Temperature Structure, Abundances, and Variability

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We have obtained high resolution X-ray spectra of the coronally active binary, II Pegasi (HD 224085), covering the wavelength range of 1.5-25Å. For the first half of our 44 ksec observation, the source was in a quiescent state with constant X-ray flux, after which it flared, reaching twice the quiescent flux in 12 ksec, then decreasing. We analyze the emission-line spectrum and continuum during quiescent and flaring states. The differential emission measure derived from lines fluxes shows a hot corona with a continuous distribution in temperature. During the non-flare state, the distribution peaks near $\log T = 7.2$, and when flaring, near 7.6. High-temperature lines are enhanced slightly during the flare, but most of the change occurs in the continuum. Coronal abundance anomalies are apparent, with iron very deficient relative to oxygen and significantly weaker than expected from photospheric measurements, while neon is enhanced relative to oxygen. We find no evidence of appreciable resonant scattering optical depth in line ratios of iron and oxygen. The flare light curve is consistent with Solar two-ribbon flare models, but with a very long reconnection time-constant of about 65 ks. We infer loop lengths of about 0.05 stellar radii, to about 0.25 in the flare, if the flare emission originated from a single, low-density loop.

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The Coronal FeXXI λ1354.094 Line in AB Doradus

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The active late-type star AB Doradus was observed in February 1996 with the Goddard High Resolution Spectrograph of the *Hubble Space Telescope* using the low resolution G140L grating. The observations covered one half of the star's rotation cycle (P = 0.514 d) with 11.5 min time resolution. The strong coronal Fe XXI λ1354.094 line formed at 10^7 K was analysed and its emission measure (EM) derived. This EM is much higher than that derived from recent XMM-Newton observations (Güdel et al. 2001), and earlier EXOSAT (Collier Cameron et al. 1988) and ASCA/EUVE (Mewe et al. 1996) data, as well, requiring a variability by a factor of 5. The physical reason for the variability remains unknown, since (outside flares) the observed broad band variability of AB Dor is much smaller.

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New Physical Elements of HR 7428 and its Hα Behaviour

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HR 7428 is a spectroscopic binary composed of a K2 II-III and a main-sequence A2 star. Thanks to a new set of radial velocity measurements from our and IUE spectroscopy we have improved the orbital period determination and the spectroscopic elements of both components. Combining optical photometry and UV low dispersion IUE spectra we have determined new stellar parameters through photospheric synthetic spectra using the NextGen models by

Hauschildt et al. (1999a, 1999b). The hot secondary component parameters agree with those of a typical A2 V star while the radius of the primary cool star turns out to be 40 $R_\odot$, i.e. significantly smaller than a previous estimate of 62 $R_\odot$. The position of the hot and cool component on the H-R diagram is consistent with a normal evolution, without any mass exchange, of this binary system, whose age is in the range 100–200 Myrs. The system displays a filled-in Hα profile with significant variations both in depth and width along the orbital phase. In addition to the Hα chromospheric emission component, we have detected, at some phases, a broad extra-absorption and emission that we relate to an inter-system cloud.

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FUSE Observations of Capella

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Far Ultraviolet Spectroscopic Explorer (FUSE) observations of the binary system Capella reveal a rich emission line spectrum containing neutral and ionic species, among them H I, O I, C III, O VI, S VI, Ne V and Ne VI. In addition, the Fe XVIII 974.85 Å line, formed at temperatures of $\approx 6 \times 10^6$ K, is detected. Whereas the strong transition region lines principally come from the G1 giant, consistent with results from previous ultraviolet observations, Fe XVIII is formed largely in the G8 giant atmosphere. Line ratios from C III suggest densities of 2–8$\times 10^{10}$ cm^{-3}, although anomalous line profiles of the λ1176 transition may signal optical depth effects.

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*Beppo*SAX Observation of a Large Long-duration X-ray Flare from UX Arietis

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We present two X-ray observations of the RS CVn binary system UX Arietis performed with *Beppo*SAX in August 1997 and August 1998. A large flare lasting for about 1 day was detected during the first observation, while the star was quiescent during the second one. Hard X-ray emission up to $\sim$ 50 keV was detected in the PDS instrument during the rise and at the peak of the flare. Time-resolved spectroscopy of the flare with the LECS and MECS detectors shows that temperatures as high as $\sim$ 100 MK were reached at the flare peak; such high temperatures are responsible for the high-energy tail seen in the PDS. We confirm that the coronal abundance of UX Ari is strongly subsolar ($Z/Z_\odot \simeq 0.2 - 0.3$); no significant variation of the metallicity is observed during the flare. We show that the new LECS response matrices released in January 2000 seem to solve the problem of the high hydrogen column densities systematically found in previous *Beppo*SAX observations of stellar coronae. We find in fact for the quiescent spectrum $N_{\rm H} = 2.6 \times 10^{19}$ cm^{-2}, compatible with the expected value; during the flare $N_{\rm H}$ is higher by a factor 5, probably due to the ejection of material. The flare evolution has been analysed using the two-ribbon flare model by Poletto et al. (1988), finding a very good agreement between the model and the observations.

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Pre-Main Sequence Dynamos and Relic Magnetic Fields of Solar-Type Stars

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We argue that contemporary magnetic fields in the radiative cores of solar-type stars are relics of hydromagnetic dynamos operating over the pre-main sequence epoch when the core formed. Simulations of differential rotation and dynamos of a $1M_{\odot}$ star are performed for a sequence of evolutionary stages of the core-growth epoch. A big difference in the dynamo-generated field between the initial and final stages of the core formation is predicted. An axisymmetric and cyclic field similar to the present day Sun is excited in a star with a mature radiative zone. An infant Sun with its core just starting to grow generates a nonaxisymmetric global field which is steady in a rotating frame. A qualitative explanation for the nonaxisymmetry is suggested. A toy-model for the field capturing by the growing core is designed. The internal field is most efficiently captured over the initial phase when the core grows most rapidly. A nonaxisymmetric global relic field with amplitude somewhat below 1G is predicted for a main-sequence star of solar mass. An interpretation for the active longitude phenomenon as observed on the Sun and stars in terms of the nonaxisymmetric relic field is suggested.

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New Neighbours. III. 13 New Companions to Nearby Dwarfs, Discovered with Adaptive Optics

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We present some results of a CFHT adaptive optics search for companions to nearby dwarfs. We identify 13 new components in solar neighbourhood systems, of which 6 belong to a volume-limited sample of M dwarfs within 12 pc. We are obtaining complete observations for this subsample, to derive unbiased multiplicity statistics for the very-low-mass disk population. We additionally resolve for the first time 5 known spectroscopic or astrometric binaries, for a total of 18 newly resolved companions. A fair number of the new binaries has short enough estimated periods to offer good prospects for accurate mass determinations.
The newly resolved companion of Gl 120.1C had an apparent spectroscopic minimum mass in the brown-dwarf range (Duquennoy & Mayor 1991), and it contributed to the statistical evidence that a few percent of solar type stars might have brown-dwarf companions. We find that Gl 120.1C actually is an unrecognised double-lined spectroscopic pair, whose radial-velocity amplitude had been strongly underestimated by Duquennoy & Mayor 1991. It therefore does not truly belong to their sample of single-lined systems with minimum spectroscopic mass below the substellar limit. We also present the first direct detection of Gl 494B, an astrometric brown-dwarf candidate. Its luminosity does straddle the substellar limit, and it is a brown dwarf if its age is less than ∼300 Myr. A few more years of observations will ascertain its status from first principles.

Submitted to A&A

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A Method to Estimate the Effect of Line Blanketing in NLTE Radiative Transfer Calculations

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We present a method to estimate the contribution of line opacity to the total opacity as a function of wavelength. The estimated line-opacity function can then be used to simulate line-blanketing in NLTE radiative transfer calculations. Given a reference flux distribution (either observed or theoretical), our method allows to obtain a good estimate of the spectrum without the need of considering in detail all the millions of lines contributing to line blanketing. We applied the method to the spectra computed from a sample of photospheric models with effective temperatures T_{eff}= 4200, 5200 and 6200 K, $\log g$= 4.0, 4.5, 5.0 and [A/H]= 0.0, -1.0, -2.0, taken from the *NextGen* database. he computed flux distributions agree quite well with the corresponding LTE line-blanketed *NextGen* fluxes when we introduce the estimated line-opacity contribution as a multiplicative factor of the continuum opacity in the radiative transfer calculations. In particular we discuss the importance of a correct estimate of the continuum flux, mainly in the UV, in the NLTE formation of the Ca II H & K, the Ca II InfraRed Triplet (IRT: λ = 8498, 8542, 8662), Na I D, Li I and K I resonance lines.

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Solar Abstracts

Origin and Evolution of Filament-Prominence Systems

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We present a “head-to-tail” linkage model for the formation, evolution, and eruption of solar filaments. The magnetic field structure of our model is based upon the observation that filaments form exclusively in filament channels with no apparent magnetic connections above the polarity inversion line. The formation of a filament in this configuration is driven by flux convergence and cancellation, which produces loop-like filaments segments with a half-turn. Filament segments of like chirality may connect and form long quiescent filaments. Such filaments are stabilized through footpoint anchoring until further cancellation at the footpoints causes their eruption. The eruption restores the original filament channel so that filament formation may resume immediately. We then demonstrate that the combined workings of Hale's polarity law, Joy's law, and differential rotation introduce a strong hemispheric preference in the chirality of filaments formed poleward of the sunspot belt, in agreement with observations. We analyze the magnetic fine structure of filaments formed through our model and find consistency with the observed hemispheric preference for barb orientation and a simple explanation for barb formation. Finally we consider the flux tubes retracted below the surface in the process of filament formation. We show that every cancellation event that generates a filament obeying the hemispheric chirality preference, injects a flux tube below the surface with a poloidal field opposite to that of the ongoing cycle. We suggest that this pattern of submergence of flux represents the specific mechanism for the reversal of the poloidal flux in a Babcock-Leighton-Durney type model for the solar dynamo.

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Approximate Isocontours for the Solar Angular Velocity in the Convection Zone

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The angular velocity, Ω, in the solar convection zone (SCZ) is expanded in Legendre polynomials, $P_n(\cos\theta)$, and the values for Ω at the equator are assumed to be given by Kosovichev's helioseismic data; here, r, θ, and ϕ, label the radial,

latitudinal and longitudinal coordinates respectively. The isocontours for Ω are calculated for the following two cases: i) The angular momentum of a thin spherical shell of radius r is identical to the shell's angular momentum for solid body rotation, i.e., rotation just distributes in latitude the angular momentum of each layer. ii) Considerations based on the Taylor-Proudman balance (a balance between the pressure, Coriolis and buoyancy forces which is expected to be amply satisfied in the SCZ), require that the radial component of the superadiabatic gradient be strongly dependent on latitude unless the coefficients in the expansion for Ω defined above satisfy a first order differential equation, DE. The isocontours for the angular velocity determined from DE, compare remarkably well with the helioseismic data, whereas for case i) there is a marked difference at high latitudes.

The radial and latitudinal balance of angular momentum are studied. The meridional motions are determined mainly (but not entirely) by the radial balance of angular momentum, and they depend principally on the Reynolds stress, $\langle u_r u_\phi \rangle$. Concerning the latitudinal balance, $\partial\Omega/\partial\theta$ increases until the transport of angular momentum toward the poles by the meridional motions is able to balance the transport of angular momentum towards the equator by $\langle u_\theta u_\phi \rangle (= \langle u_\theta u_\phi \rangle_0 - \nu_t \sin\theta \partial\Omega/\partial\theta))$. Here the subscript 0 stands for solid body rotation, and ν_t is a turbulent viscosity coefficient. In contrast to the radial balance, the viscosity term plays a fundamental role in the latitudinal balance of angular momentum.

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The Sun as an X-ray Star: IV. The Contribution of Different Regions of the Corona to its X–ray Spectrum

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We study X–ray synthesized spectra of solar regions as templates to interpret analogous stellar spectra. We define three classes of coronal structures of different brightness, low (background quiet corona), medium (active regions), high (active regions cores), and determine their contribution to the solar X–ray emission measure vs. temperature, EM(T), luminosity and spectrum. This study defines the extent of the solar analogy quantitatively and accurately.

To this end, we have selected a large sample of full–disk Yohkoh/SXT observations taken between the maximum and the minimum of solar cycle 22, obtaining the contribution of each class to the whole Sun's EM(T). From the EM(T) distributions we synthesize the X–ray spectra of the Sun and of the single classes of solar coronal regions as they would be collected with ROSAT/PSPC and ASCA/SIS. We find that the Sun during the cycle fits well in the stellar scenario as a low activity star. The ROSAT/PSPC hardness ratio HR and surface X–ray flux F_{PSPC} both increase going from the background corona to the active regions, to the cores of active regions, and range between the values of low and intermediate activity stars. We suggest that the coronae of these stars may be explained as the effect of structures similar to those present on the Sun and that the various levels of X–ray luminosity, HR and F_{PSPC} are achieved changing the surface coverage of the different classes of coronal regions.

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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), brown dwarfs, 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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