COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

The Henize Sample of S stars. I. The Technetium Dichotomy

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This paper is the first one in a series investigating the properties of the S stars belonging to the Henize sample (205 S stars with $\delta < -25°$ and $R < 10.5$) in order to derive the respective properties (like galactic distribution and relative frequencies) of intrinsic (i.e. genuine asymptotic giant branch) S stars and extrinsic (i.e. post mass-transfer binary) S stars. High-resolution (R=30 000 to 60 000) spectra covering the range $\lambda\lambda 4230 - 4270$Å have been obtained for 76 S stars, 8 M stars and 2 symbiotic stars.

The λ4262Å and λ4238Å blends involving a Tc I line were analysed separately and yield consistent conclusions regarding the presence or absence of technetium. Only one 'transition' case (Hen 140 = HD 120179, a star where only weak lines of technetium are detectable) is found in our sample. A resolution greater than R = 30 000 is clearly required in order to derive unambiguous conclusions concerning the presence or absence of technetium. The Tc/no Tc dichotomy will be correlated with radial velocity and photometric data in a forthcoming paper.

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Doppler Imaging of Stellar Surface Structure. X. The FK Comae-type star HD 199178 = V1794 Cygni

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Doppler imaging is used to derive the surface temperature distribution of the FK Comae star HD 199178 for five observing epochs between 1988 and 1997. Our maps are mainly based on Ca I 6439-Å line profiles and simultaneous and contemporary BV and VI photometry. All images of HD 199178 are characterized by a large polar spot and several low-latitude spots with an average surface temperature difference, photosphere minus spots, of 710±260(rms) K for the equatorial spots, ≈1700 K for the polar spot, and 1300±300(rms) K for the polar-spot appendages. The lifetime of some of the low-latitude spots was found to be as short as one month or even less. The lifetime of the polar spot and most of its very cool appendages must exceed the time of our observations, i.e. 9 years or approximately 1000 stellar rotations, and could be as long as 12 years since its discovery by Vogt in 1985. Two consecutive Doppler maps in 1989 show no evidence for differential surface rotation, nor is there substantial evidence for the existence of active longitudes in any of our five images. Instead, we suspect that most of the time variability of the surface features on HD 199178 is short term and possibly chaotic in origin. We conclude that spot lifetimes estimated from the timing of light-curve minima could lead to grossly overestimated lifetimes of individual spots.
With the aid of our optical spectra and the Hipparcos parallax, we redetermine the absolute stellar parameters of HD 199178 and confirm it to be a single G5III-IV star and find 1.65 $M_\odot$ and 11 $L_\odot$ with $T_{\rm eff} \approx 5450$ K, $\log g = 2.5$, and solar abundances.

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Evolved, Single, Slowly Rotating ... but Magnetically Active. The G8-giant HR 1362 = EK Eridani Revisited

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We rediscuss the unusual case of the slowly rotating late-type giant HR 1362, which exhibits a very unusual high level of magnetic activity. New BVRI photometry from two robotic telescopes from 1991 through 1998 together with previously published photometric data gives a very precise photometric period of 306.9±0.4 days. With the aid of high-resolution (R=120,000) optical spectra and the Hipparcos parallax we redetermine the absolute parameters of HR 1362 and find it to be a single G8IV-III star of 14 $L_\odot$ and a mass of 1.85 $M_\odot$ with $T_{\rm eff}$=5125 K, $\log g$=3.25, and solar abundances. Lithium is not significantly different from solar and we obtain $\log n$(Li)=1.14 from a detailed spectrum synthesis including both isotopes at 6708 Å. $V sini$ and macroturbulence are determined from fits of disk-integrated models to the observed line profiles as well as their Fourier transforms and are 1.5 ± 0.5 km/s and ≈5 km/s , respectively. The minimum radius from $v \sin i$ and $P_{\rm rot}$ is only then in agreement with the spectral classification and the bolometric luminosity from the Hipparcos parallax if the inclination of the stellar rotation axis is nearly 90 degrees. We concur with the arguments of Stępień that HR 1362 is an evolved Ap star, and therefore the magnetic field is possibly of galactic origin rather than dynamo generated.

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Precise Radial Velocities of Proxima Centauri. Strong Constraints on a Substellar Companion

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We present differential radial velocity measurements of Proxima Centauri collected over 4 years with the ESO CES with a mean precision of 54 ms^{-1}. We find no evidence of a periodic signal that could corroborate the existence of a sub-stellar companion. We put upper limits (97% confidence) to the companion mass ranging from 1.1 to 22 $\mathrm{M_{Jup}}$ at orbital periods of 0.75 to 3000 d, i.e. separations $0.008 - 2$ AU from Prox Cen. Our mass limits concur with limits found by precise astrometry (Benedict et al. 1998a and priv. comm.) which strongly constrain the period range $50 - 600$ d to $1.1 - 0.22$ $\mathrm{M_{Jup}}$. Combining both results we exclude a brown dwarf or supermassive planet at separations $0.008 - 0.69$ AU from Prox Cen. We also find that, at the level of our precision, the RV data are not affected by stellar activity.

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Evolution of Chromospheric Activity: M67 Red Giants

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Echelle spectra of the Ca II H and K line region (λ3950) of 15 red giant stars in the open cluster M67 reveal atmospheric dynamics and determine chromospheric radiative losses in order to assess chromospheric heating requirements and to follow the evolution of chromospheric activity. M67 red giants in conjunction with giants in younger clusters create a continuous group of red giants in the color-magnitude diagram, with $0.1 \leq (B-V) \leq 1.65$ along the red giant branch. M67 contains the more evolved clump giants as well. Asymmetric line emission cores, indicative of outflowing material are found in a majority of the M67 giants on the red giant branch and occur over the complete sample: from $M_V = -0.8$ to $M_V = 1.9$, suggesting that outward mass motions are well-established at these luminosities. Radiative losses, as measured by emission strengths from Ca II, decrease smoothly with decreasing stellar effective temperature in M67 and connect well to a combined sample of warmer cluster giants (NGC 2477, IC 4756, and the Hyades) with $M \leq 3\ M_\odot$ studied by Beasley & Cram. Stellar effective temperature predominantly determines the level of chromospheric Ca II losses for giants with $M \leq 3\ M_\odot$. No evidence is found for a sharp decline in the flux of Ca II predicted by the Rutten & Pylyser magnetic model for chromospheric heating. However, emission in field giants (which tend to be younger) suggests that sharp declines in surface flux with decreasing effective temperature characteristic of pure magnetic activity, occur for ion species more highly excited than Ca II. Although acoustic models for chromospheric heating apparently agree with the measured Ca II flux levels for the coolest giants, additional heating processes must be present in warmer giants and clump stars. Clump giants exhibit Ca II fluxes consistent with stars of similar colors on the red giant branch, suggesting a renaissance in chromospheric heating occurs after evolution beyond the red giant branch. Chromospheric heating in the giants of solar metallicity is likely to be derived from multiple sources, both hydrodynamic causes as well as magnetically-related processes. The relative contribution of each heating mechanism changes with temperature in the stellar atmosphere, and these proportions may change during a star's evolution from the main sequence.

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A *Beppo*SAX Observation of HD 9770: A Visual Triple System Containing a Recently Discovered Short-Period Eclipsing Binary

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We have studied the coronal X-ray emission of the recently discovered short-period eclipsing binary HD 9770 with the *Beppo*SAX satellite. The data from the Low Energy and Medium Energy Concentrator Spectrometers (LECS & MECS) onboard *Beppo*SAX allow studying the spectrum of this star from 0.1 to 8 keV, confirming that this is a very active coronal source, with strong flaring activity. The X-ray emission most likely originates from the eclipsing binary itself, rather than from the other visual component of the system. The X-ray light curves could be modulated with the orbital period of the eclipsing binary, with a hint for a different orbital modulation of the cooler and hotter plasma. The X-ray spectrum is characterized by hot plasma, with the Fe K complex at 6.7 keV clearly detected in the MECS spectrum, and it is well fitted by a 2-temperature optically thin plasma model with low metal abundances ($\sim 0.3\ Z\odot$). These results are in line with those found for many other active stars. As expected, during the flare the X-ray emission is dominated by hotter plasma with a temperature > 4 keV. There is an indication that the metal abundance may be somewhat higher during the flare.

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Solar Abstracts

Angular Momentum Transport in Magnetized Stellar Radiative Zones. IV. Ferraro's Theorem and the Solar Tachocline

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We consider the circumstances under which the latitudinal differential rotation of the solar convective envelope can (or cannot) be imprinted on the underlying radiative core through the agency of a hypothetical weak, large-scale poloidal magnetic field threading the solar radiative interior. We do so by constructing steady, 2-D axisymmetric solutions to the coupled momentum and induction equations under the assumption of purely zonal flow and time-independent poloidal magnetic field.

Our results show that the structure of the interior solutions is entirely determined by the boundary conditions imposed at the core-envelope interface. Specifically, in the high Reynolds number regime, a poloidal field having a non-zero component normal to the core-envelope interface can lead to the transmission of significant differential rotation into the radiative interior. In contrast, for a poloidal field that is contained entirely within the radiative core, any differential rotation is confined to a thin magnetoviscous boundary layer located immediately beneath the interface, as well as along the rotation/magnetic axis.

We argue that a magnetically decoupled configuration is more likely to be realized in the solar interior. Consequently, the helioseismically inferred lack of differential rotation in the radiative core does not necessarily preclude the existence of a weak, large-scale poloidal field therein. We suggest that such a field may well be dynamically significant in determining the structure of the solar tachocline. Accepted by ApJ

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A Search for Companions to Nearby Brown Dwarfs: the Binary DENIS-P J1228.2-1547

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Hubble Space Telescope near infrared camera and multiobject spectrometer (NICMOS) imaging observations of two nearby young brown dwarfs, DENIS-P J1228.2-1547 and Kelu 1, show that the DENIS object is resolved into two components of nearly equal brightness with a projected separation of 0.275 arcsec (5 astronomical units for a distance of 18 parsecs). This binary system can provide the first dynamical measurement of the masses of two brown dwarfs in only a few years. Upper limits to the mass of any unseen companion in Kelu 1 yield a planet of 7 Jupiter masses and age 0.5×10^9 years, that would have been detected at a separation larger than $\sim$4 astronomical units. This example demostrates that giant planets could be detected by direct imaging if they exist in Jupiter-like orbits around nearby young brown dwarfs.

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Job Announcement

Postdoctoral Research Associate
Dept. of Physics and Astronomy
University of Leicester

A Postdoctoral Research Associate position is available at the University of Leicester to work on Brown Dwarfs. The salary scale is RA1A £15,735 - 23,651 p.a. (lower end of scale) Closing date for applications is 19 March 1999.

Applications are invited to undertake research into brown dwarfs funded by PPARC. Applicants should have (or expect soon to have) a relevant PhD. Experience of the brown dwarf or stellar field and appropriate observational/analysis techniques is desireable, but not essential. The position is available immediately for 3 years. Informal enquiries may be made to Dr. Richard Jameson, tel: +44 (0)116 252 2074, fax: +44 (0)116 252 2070, email: rfj@star.le.ac.uk).

Application forms and further particulars may be obtained from the Personnel Office (Appointments), University of Leicester, University Road, Leicester LE1 7RH. (Tel: +44 (0)116 252 2439, email: efd1m@admin.le.ac.uk).

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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, or M) 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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