COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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TABLE OF CONTENTS

Stellar Abstracts

The Revised X-ray Dividing line: New Light on Late Stellar Activity

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Based on new pointed ROSAT data, we revise the X-ray dividing line for late-type giants in the HR diagram. We compare the new data with well calibrated evolutionary tracks and suggest that the resulting picture can entirely be understood as a consequence of the different evolutionary history of stellar activity in different mass-ranges. In particular, hot coronae disappear slowly in the course of stellar evolution, since the evolutionary tracks are parallel to the revised X-ray dividing line and do *not* cross it. Furthermore, hybrid stars turn out to be quite common: they are just more massive, more active and maintain some coronal plasma *beyond* the onset of cool winds. Hence, the latter may be mostly *independent* of the decrease of stellar activity.

Accepted by A&A Letters

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HR 4289 – An X-ray Luminous Galaxy Close to the Bright Star

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Using new optical, UV and X-ray observations we show that the K5 III star HR 4289, formerly believed to be the only ROSAT All-Sky survey detection to the right of the coronal diving line, should not be identified with the X-ray source. Pointed ROSAT PSPC observations demonstrate that the X-ray source is slightly extended, and locate the X-ray source 30" northwest of HR 4289 at the position of a hitherto unknown 15^m galaxy. The X-ray spectrum can well be fitted with a Raymond-Smith model for a thermal plasma at $6(\pm 2)\cdot 10^6$K and a hydrogen column density of $N_{\rm H} = 3(\pm 2)\cdot 10^{21}{\rm cm}^{-2}$. At a distance of $z = 0.016$ (96 h_{50}^{-1} Mpc), the galaxy has an X-ray luminosity of $L_{\rm x} = 1.4\cdot 10^{42}$ h_{50}^{-2} erg s^{-1} between 0.1 and 2.4 keV.

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Accurate Mass Determination for Double-Lined Spectroscopic Binaries by Digital Cross-Correlation Spectroscopy: DM Virginis Revisited

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Fundamental mass determinations in eclipsing binaries rely on radial velocities derived from double-lined spectra. We evaluate the performance of the CfA Digital Speedometers for deriving radial velocities of double-lined systems, using simulated observations of composite spectra. When XCSAO (Kurtz et al. 1992) is used to calculate a one-dimensional cross-correlation, simple fits to the double peaks in the correlation function can lead to systematic errors as large as 3 km s^{-1} due to the effects of line blending. The two-dimensional correlation scheme TODCOR (Zucker & Mazeh 1994) can reduce the systematic errors by an order of magnitude. We apply TODCOR to a new mass determination for the F-type eclipsing binary DM Vir, achieving an accuracy of 0.6%. The improved physical properties of DM Vir agree very well with stellar evolution models incorporating the most recent opacity data, both with and without convective core overshooting, and for reasonable assumptions about the chemical composition. The age of DM Vir is found to be $1.75 \pm 0.20 \times 10^9$ yr, metallicity being the dominant source of uncertainty.

Accepted by A&A

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The Neupert Effect in Active Stellar Coronae: Chromospheric Evaporation and Coronal Heating in the dMe Flare Star Binary UV Ceti

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Evidence for coronal heating by chromospheric evaporation in flares of active dMe stars is presented through observations of the Neupert effect in high-frequency microwaves and soft X-rays. The Neupert effect, as originally found in solar flares, manifests itself in a close similarity between the soft X-ray light curve and the time integral of the simultaneous microwave light curve. It is interpreted as the signature of the accumulation of hot plasma due to heating by accelerated electrons in the chromosphere.

We used the ROSAT and ASCA soft X-ray observatories and the Very Large Array (VLA) radio telescope (at 6 cm and 3.6 cm wavelengths) to simultaneously monitor the nearby dMe flare star binary Gliese 65 A+B = UV Ceti during 9 hours each on two consecutive days. We find several only moderately polarized radio events that start contemporaneously (within a few minutes) with X-ray flares and then peak and decay as the X-ray flares develop gradually. A striking similarity with the temporal evolution of solar gradual events is found. We argue that the Neupert effect is best observable in relatively hard bands of the soft X-ray emission, and that its presence can be implied from the much softer bands commonly used for stellar observations by use of the solar analogy. Together with spectral hardness observations of soft X-rays, the data suggest the operation of chromospheric evaporation on UV Ceti. The observations thus indicate a *causal* relation between the nonthermal and thermal energies of the underlying electron populations.

We find that stellar flares are, relative to solar flares, X-ray weak. The ratio between the total energy radiated into the radio and the soft X-ray bands closely matches the corresponding ratio between the quiescent luminosities of active stars, perhaps implying similar mechanisms and similar efficiencies for the quiescent emission and for larger, single flares. Estimating the total kinetic energy in the electrons from the radio flux, we find that only a fraction is observed in soft X-rays, a discrepancy well known from solar flares.

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UBVRI Photometric Monitoring of 7 Rapidly Rotating Late-type Dwarfs in the Alpha Persei Cluster.

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The UBVRI light curves of 7 late-type dwarfs amongst the fastest rotators of the Alpha Per cluster ($v\sin i \geq 140$ kms^{-1}) are presented. The shape of the light curves suggests that the photometric variations are most often dominated by a single group of cool spots located at intermediate or high latitude on the stellar surface. Assuming that starspots are good tracers of the stellar magnetic field, the smooth light curves indicate the existence of a large scale, slowly varying magnetic structure at the surface of these ultrafast rotators.

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ROSAT Observations of Five Chromospherically Active Stars

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We present X-ray spectra of three chromospherically active binaries, HR 7428, FF Aqr, and IX Per, and two active giant stars, 29 Dra and HR 9024. The spectra were obtained using the Position Sensitive Proportional Counter (PSPC) on the *ROSAT* satellite. For coronal plasma models with 1-temperature or 2-temperature components, we find that a range of heavy element abundances, from solar to extreme sub-solar abundances similar to those that have been inferred from analyses of *ASCA* spectra, provide acceptable fits to the observed PSPC spectra. The highest signal-to-noise spectrum of 29 Dra requires either a 1- or 2-temperature model with greatly sub-solar (photospheric) abundances or else a 3-component model with solar abundances. The degeneracy of these results, i.e., the fact that quite different models can produce acceptable fits to the PSPC spectra, means that it is difficult to infer the temperature structure of a corona from a PSPC spectra analysis without *a priori* knowledge of the prevailing coronal abundances, and *vice versa.* We also show that uncertainties in the intervening interstellar column densities can affect the inferred temperatures and/or abundances. Notwithstanding these difficulties, our analysis confirms that models having similar subsolar abundances to those inferred from *ASCA* and *EUVE* spectra of active coronal stars do indeed produce good fits to PSPC spectra. This general consistency between different instruments implies that explanations for the subsolar abundances that invoke systematic biases due to instrumental effects can now be ruled out.

Accepted by AJ

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Doppler Imaging of Stellar Surface Structure.
I. The Rapidly-rotating RS CVn Binary UZ Librae

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We present the first Doppler image of the rapidly-rotating K0III star of the single-lined RS CVn binary UZ Librae. Our analysis incorporates line profile variations from three spectral regions (around Ca I 6439 Å, Fe I 6411 Å and Fe I 6393 Å) and continuum variations from simultaneous *VRI* photometry. All images recover a polar feature consisting of mainly three "appendages" between latitudes of +60° and +80°. This polar feature is not like a polar cap as previously seen on other RS CVn stars but consists primarily of the three appendages. Up to six equatorial features were also detected and have temperature differences between 200 and 400 K cooler than the photospheric temperature of 4800 K.

Images from individual spectral lines show an encouraging amount of consistent detail, especially for the location but also for the shape of certain features. The recovery of the temperature scale is on average also similar but can be somewhat different for particular surface features. This is most noticable for the larger of the three polar appendages; we found it 30% cooler from the Ca I line and the Fe I 6411-Å line than from the Fe I 6393-Å line. We suspect such differences are partially due to external errors of the line profile data and slightly inaccurate input physics.

New photometry and radial velocity measurements are used to recompute the photometric period and the orbital elements of UZ Librae.

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Strömgren Four-colors Photometry of X-ray Active Late-type Stars: Evidence for Activity-induced Deficiency in the m_1 Index

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We present the results of a *uvby-β* photometric study of a sample of active late-type stars (F–K) selected from the *Einstein* Extended Medium Sensitivity Survey. Our work shows the presence in the sample of a star population with the photometric index c_1 typical of main sequence stars and an unexpected deficiency in m_1 index. Stars with more anomalous values of m_1 have also very high values of f_X/f_V and X-ray surface fluxes, near the "saturation" limit observed in the most active stars and similar to the flux observed in solar active regions. We discuss these results in the light of similar results found in the Sun, comparing m_1 indices in quiet and active regions and in other samples of active stars.

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2RE J0241-525: A Nearby Post T-Tauri Visual Binary System

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We present high spatial resolution X-ray observations, photometry and spectroscopy of the two low mass, active stars proposed as optical counterparts to the extreme ultra-violet source 2RE J0241-525 (= EUVE J0241-530). It is confirmed that both stars, which are of types dK7e and dM3e and separated by 22 arcsecs, are sources of soft X-ray emission and exhibit substantial chromospheric activity. Radial velocity measurements indicate that the two

components are physically associated and probably single. The projected equatorial velocities are measured as $(75 \pm 3)\,\mathrm{km\,s^{-1}}$ and $(11.7 \pm 0.7)\,\mathrm{km\,s^{-1}}$ for the hotter and cooler components respectively and whilst the hotter component has a relatively high photospheric lithium abundance, $\log \mathrm{N(Li)} = 1.5 \pm 0.2$, we are unable to detect lithium in the cooler star. Isochrone fitting to this "mini-cluster" yields an age of (3-70) Myr and a distance of (19-60) pc. An empirical comparison of the lithium abundances with those for similar stars in young clusters and associations suggests a narrower age range of (5-30) Myr and a corresponding distance of (26-50) pc. We conclude that the object is a nearby post T-Tauri system, but we cannot locate any possible birth site. It appears unlikely that the system can have been ejected from a nearby open cluster in a two or three body encounter.

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Spectroscopy of New Substellar Candidates in the Pleiades: Towards a Spectral Sequence for Young Brown Dwarfs

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We present optical and near-infrared spectroscopy (600–1000 nm) of eight faint (I>18) very red (R–I>2.2) objects discovered in a deep CCD survey of the Pleiades cluster (Zapatero Osorio et al. 1996). We compare them with reliable cluster members like PPl 15 and Teide 1, and with several field very late-type dwarfs (M4–M9.5), which were observed with similar instrumental configurations.

Using pseudocontinuum ratios we classify the new substellar candidates in a spectral sequence defined with reference to field stars of known spectral types. We also reclassify PPl 15 and Teide 1 in a self-consistent way. The likelihood of membership for the new candidates is assesed via the study of their photospheric features, Hα emission, radial velocity, and consistency of their spectral types and I-band magnitudes with known cluster members. Four of the new substellar candidates are as late or later than PPl 15 (M6.5), but only one, namely Calar 3 (M8), clearly meets all our membership criteria. It is indeed an object very similar to the brown dwarf Teide 1.

Out of the eight new substellar candidates, our "cautious" membership analysis leaves only Calar 3 as a Pleiades brown dwarf with a high level of confidence. This object, together with Teide 1, allows one to compare the spectroscopic characteristics of Pleiades brown dwarfs with those of old very cool dwarfs. The overall spectral properties are similar, but there are slight differences in the NaI doublet (818.3 nm, 819.5 nm), VO molecular band (740 nm), and some spectral ratios, which are probably related to lower surface gravity in the young Pleiades brown dwarfs than in field stars. Finally, we propose a way of improving future CCD-based brown dwarf surveys by using narrow-band near-IR pseudocontinuum filters.

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K Giants in 47 Tucanae: Detection of a New Class of Variable Stars

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We report the discovery of variability among K giants in the globular cluster 47 Tucanae, using a time series of U exposures with *HST*. The variables lie along a narrow band in the CMD joining the faint end of the AGB to the RGB. The variations, if coherent, mostly have periods between $\sim$2 and $\sim$4 days, consistent with low overtone radial pulsation or nonradial pulsation, and V amplitudes in the range 5–15 mmag, explaining their nondetection so far in clusters. One of the variables may have a period of 1.1 days and a V amplitude of 5.3 mmag. These stars define a new class of variable stars and probably contain variable field K giants such as α Boo as members. An understanding of their variations may have significant ramifications for theories of stellar structure and stellar evolution.

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$JHKL$ Photometry and the $K-$band Luminosity Function at the Galactic Center

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J, H, K, and L photometry for the stars in the central $\sim 2'$ (~ 5 pc) of the Galaxy are presented. Using the observed $J-H$, $H-K$, and $K-L$ colors and assumed intrinsic colors, we determine the interstellar extinction at 2.2 μm (A_K) for approximately 1100 individual stars. The mean A_K (= 3.3 mag) is similar to previous results, but we find that the reddening is highly variable and some stars are likely to be seen through $A_K > 6$ mag. The de–reddened $K-$band luminosity function points to a significantly brighter component to the stellar population (> 1.5 mag at K) than found in the stellar population in Baade's window, confirming previous work done at lower spatial resolution. The *observed* flux of all Galactic center stars with estimated $K_\circ$ (de–reddened magnitude) ≤ 7.0 mag is ~ 25 % of the total in the $2' \times 2'$ field.

Our observations confirm the recent finding that several bright M stars in the Galactic center are variable. Our photometry also establishes the near–infrared variability of the M1–2 supergiant, IRS 7.

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Simultaneous Hα, Na I D$_1$, D$_2$, and He I D$_3$ Observations of a Flare on the RS CVn System UX Ari

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We present simultaneous Hα, Na I D$_1$, D$_2$, and He I D$_3$ spectroscopic observations on the RS CVn system UX Ari. We have found a dramatic increase in the excess Hα emission equivalent width by a factor of 2 in an interval of 1 day that indicates the beginning of a strong flare in this system. The presence of the He I D$_3$ in emission in coincidence with the enhancement of the Hα emission confirms the detection of a flare. The application of the spectral subtraction technique reveals that the core of the Na I D$_1$ and D$_2$ lines are also filled-in by chromospheric emission.

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Solar Abstracts

Yohkoh Observations of Fe XXVI X-ray Line Emission from Solar Flares

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This paper reports on observations from the Bragg Crystal Spectrometer (BCS) on board the Japanese solar flare spacecraft *Yohkoh* showing Fe XXVI Ly-α X-ray line emission at 1.78 Å. Some 75 events over a two-year-long period between 1991 December 6 and 1993 December 31 have been analyzed. The greater sensitivity of the BCS compared with previous instruments has enabled such emission to be detected from a wider group of flares than has previously been possible. The likelihood of detecting Fe XXVI lines in a flare is found to increase sharply with the electron temperature obtained from the Fe XXV line spectrum, also observed by the BCS, and with *GOES* X-ray class. The width of the Lyα_1 line, measured after the impulsive stage, is rather greater than that determined by thermal Doppler broadening, but this is explained by the non-zero spatial extent of flares. Electron temperatures from the intensity ratio of a nearby feature due to Fe XXV dielectronic satellites and the Fe XXVI Lyα_1 line are obtained from new atomic parameters from the SUPERSTRUCTURE code, details of which are described. This revises earlier calculations which have been extensively used. Comparison of these temperatures with those from the Fe XXV spectra provides evidence for a single loose grouping of flares, with the difference between the two temperatures ranging from nearly zero to about 20MK. A "superhot" component would seem to be more or less developed according as the temperature difference is large or nearly zero. Flares at both extremes are examined in detail. The gradually varying part of the 14–33 keV X-ray emission as observed by the Hard X-ray Telescope on *Yohkoh* for these events has a hardness ratio corresponding to temperatures and emission measures similar to those from Fe XXVI line ratios, pointing to a common origin for their emission. Many of the flares studied occurred in particular active regions with great magnetic complexity, though Fe XXVI flares do not seem to be a distinct class within large X-ray flares.

Accepted by ApJ

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High Coronal Electron Densities in a Solar Flare from Fe XXI and Fe XXII X-ray Line Measurements

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New calculations of the intensities of the Fe XXI $2p^2 - 2p\,4l$ X-ray lines using the distorted wave method are described and compared with observations made by a crystal spectrometer on *Solar Maximum Mission* about six minutes after the peak of a very intense flare. The comparison enables the electron density of the flare to be derived, the value being about 2 or 3×10^{12} cm^{-3}. Some nearby Fe XXII X-ray lines, scanned one minute after flare peak, give an even higher value, 10^{13} cm^{-3}. This is the first time corroborated values of such high densities have been obtained from ions emitted at temperatures as high as $\sim$ 10MK. They imply very rapid radiation cooling rates, and have other important consequences for flare models.

Accepted by ApJ

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Yohkoh Observations as a Means of Checking S, Ca, and Fe Coronal Abundances and He-like Ionization Fractions

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Electron temperatures are derived from X-ray spectra observed by the Bragg Crystal Spectrometer on the *Yohkoh* satellite during long-duration solar flares, and it is found that in the late stages of such events the emitting plasma is nearly isothermal. This fact enables us to examine the accuracy of the fractional abundances of He-like S, Ca, and Fe ions as well as the ratios of coronal element abundances. Using currently accepted values for ionization fractions and our own values of element abundances, we find that adjustments of $\lesssim$ 50% or less appear to be needed.

Submitted to ApJ

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New Solar Models Including Helioseismological Constraints and Light-Element Depletion

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We have computed new solar models using the same stellar evolution code as described in Charbonnel, Vauclair and Zahn (1992). This code, originating from Geneva, now includes the computation of element segregation for helium and 12 heavier isotopes. It may also include any type of mixing of the stellar gas, provided this mixing can be parametrized with an effective diffusion coefficient as a function of radius. Here we introduced rotation-induced mixing as prescribed by Zahn (1992). We present five solar models: 1) the standard model, computed with heavy element abundances as given by Grevesse (1991); 2) a model including pure element segregation (no mixing outside the convective zone) with Grevesse (1991) as initial abundances; 3) same model as (2), but iterated so that the final abundances are those of Grevesse (1991); 4) a model with both element segregation and rotation-induced mixing, leading to lithium and beryllium depletion consistent with the observations, with Grevesse (1991) as initial abundances; 5) same model as (4) but iterated to obtain Grevesse (1991) as final abundances. This model (5) now represents our best new solar model consistent with the observations. The $u = \frac{P}{\rho}$ function computed as a function of radius in these new solar models are compared to the helioseismological results obtained for the same function by Dziembowski et al (1994). Improving the physics of the models leads to a better consistency with helioseismology. In our best model (5), which includes both segregation and mixing, the relative difference in the u function between the model and the helioseismological results is smaller than 0.5 per cent at all radii except at the center and the surface. Meanwhile lithium is depleted by a factor 155 and beryllium by a factor 2.9, which is consistent with the observations. The bottom of the convective zone lies at a fractional radius of 0.716, consistent with helioseismology. The neutrino fluxes are not decreased in any of these models.

The models including the computations of element segregation lead to a present surface helium abundance of: Y_{surf} between 0.248 and 0.258, which is in satisfactory agreement with the value derived from helioseismology.

Accepted by A&A

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Announcements

Stellar Oscillations Network Group: From the Sun to the Stars

A Special Session at Madison Meeting of the AAS, 9-13 June, 1996

The detection and study of oscillations in solar-type stars is a natural extension of the scientific goals of helioseismology. In view of the recent encouraging developments in asteroseismology and the announcement of the first results from the initial operation of the full GONG network at the Madison AAS meeting, it is time to develop a coordinated, community wide effort to achieve the potential that asteroseismology offers for progress in stellar physics, stellar structure, and stellar evolution. An effort of this magnitude can only succeed if it is truly community based.

As a first step, we are organizing a special session at the Madison meeting of the AAS to invite community participation in a new project, the Stellar Oscillations Network Group, to detect and study oscillations in solar-type stars. A Steering Committee, whose members are John Bahcall, Sam Barden, Tim Bedding, Tim Brown, Pierre Demarque, Mark Giampapa, Ron Gilliland, Jack Harvey, Frank Hill, Steve Kawaler, Christoph Keller, Hans Kjeldsen, Bob Noyes, and Caty Pilachowski, has put together the following program for the session.

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*********************************************************************************************
*                                                                                           *
*                              Program for the S.O.N.G. Special Session                     *
*                       at the Madison Meeting of the American Astronomical Society         *
*                                     2:00 - 3:30 PM, 10 June 1996                          *
*                                                                                           *
*                  2:00-2:20   Pierre Demarque     "What can we learn from astero-          *
*                                                   seismology of solar type stars?"        *
*                                                                                           *
*                  2:20-2:40   Tim Brown           "Where do we stand?"                     *
*                                                                                           *
*                  2:40-3:00   Sam Barden          "Instrumentation, protocols, and         *
*                                                       networks"                           *
*                                                                                           *
*                  3:00-3:30   Panel Discussion    "How do we make it happen?"              *
*                                                                                           *
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We hope all who are interested in learning about or participating in the S.O.N.G project will join us for this Special Session. If you are unable to attend, or would like further information, please contact C. Pilachowski at catyp@noao.edu, or visit our Web site via http://www.noao.edu (click on "S.O.N.G.").

Caty Pilachowski (on behalf of the Stellar Oscillations Network Group)

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. 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 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. 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` .