COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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EDITOR'S NOTE: NO MARCH ISSUE

Due to extended travel and lack of computer access, I will not be able to send out a March issue of Coolnews. The next issue will be mailed out around April 1 and will include those abstracts received during February and March. Abstracts are due on March 31.
Steve Skinner (ed.)

Stellar Abstracts

Multiperiodic Light Variations of Active Stars

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We studied the long-term light behaviour of ten rapidly-rotating active stars (LQ Hya, V833 Tau, EI Eri, V711 Tau, BY Dra, HU Vir, IL Hya, VY Ari, HK Lac, IM Peg) with Fourier analysis. Using photometric databases of up to 30 years in length, we search for periodic or quasi-periodic long-term variations of the overall light levels. Out of the ten stars studied, nine show cyclic variability and six of those seem to vary on two or multiple time-scales. Using additional data from the literature, we found that cycle lengths were generally longer for stars with longer rotation periods. The inverse Rossby numbers of these stars show a correlation with $\omega_{cyc}/\Omega (= P_{rot}/P_{cyc})$ calculated from the shortest cycle length. The cycle lengths of several stars agree well with other types of cycles determined earlier.

Using artificial test data, we found that the cyclic variation of the average light level is determined by the change in the spot/plage coverage alone and that spot migration does not play a significant role in the shape or length of the long-term brightness changes.

Accepted by A&A

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Doppler Imaging of Stellar Surface Structure. XII.
Rapid Spot Changes on the RS CVn Binary V711 Tau = HR 1099

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We present a time series of Doppler images of the RS CVn binary V711 Tauri from spectra taken during 57 consecutive nights in November and December 1996. VRI-band APT photometry throughout the entire observing season is used to support the Doppler imaging. A set of altogether 37 overlapping images from the Ca I-6439 line allows us to trace the latitudinal and longitudinal migration of individual starspots and their morphological evolution. We confirm the poleward migration scenario discovered by Vogt & Hatzes (1996) and obtain an average latitudinal migration rate of $+0.41\pm0.23$ (rms) °/day. Of the five spots detected, one was migrating clockwise and one counter clockwise with respect to the orbital period. One feature possibly changed its direction of migration. The two dominating polar features remained at their respective longitudes. Therefore, we are unable to fully attribute the poleward migration to differential rotation and suggest that a combination of differential rotation, meridional circulation, and local crosstalk between starspots causes the observed migration pattern. For one low-latitude spot, the latitudinal migration was briefly interrupted and seen to reverse before it resumed its poleward migration. We possibly witnessed the merging of two spots after they got too close to each other. One spot became significantly cooler shortly before it merged with the bigger and already cooler polar spot, suggesting that some flux exchange took place likely due to a partial reconnection of their magnetic field lines. The polar spot appeared in our images as a non-axisymmetric feature barely covering the actual stellar rotation pole and was not a cap-like feature as seen in several previous maps. Relative spot temperatures varied between 400 K for the weakest features and 1100 K for the main polar spot.

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The Vienna-KPNO search for Doppler-imaging Candidate Stars.
I. A Catalog of Stellar-activity Indicators for 1058 Late-type Hipparcos Stars.

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We present the results from a spectroscopic Ca II H&K survey of 1058 late-type stars selected from a color-limited subsample of the *Hipparcos* catalog. Out of these 1058 stars, 371 stars were found to show significant H&K emission, most of them previously unknown; 23% with strong emission, 36% with moderate emission, and 41% with weak emission. These spectra are used to determine absolute H&K emission-line fluxes, radial velocities, and equivalent widths of the luminosity-sensitive Sr II line at 4077 Å. Red-wavelength spectroscopic and Strömgren y photometric follow-up observations of the 371 stars with H&K emission are used to additionally determine the absolute Hα-core flux, the lithium abundance from the Li I 6708 Å equivalent width, the rotational velocity $v\sin i$, the radial velocity, and the light variations and its periodicity. The latter is interpreted as the stellar rotation period due to an inhomogeneous surface brightness distribution. 156 stars were found with photometric periods between 0.29 and 64 days, 11 additional systems showed quasi-periodic variations possibly in excess of $\approx$50 days. Further 54 stars had variations but no unique period was found, and four stars were essentially constant. Altogether, 170 new variable stars were discovered. Additionally, we found 17 new SB1 (plus 16 new candidates) and 19 new SB2 systems, as well as one definite and two possible new SB3 systems. Finally, we present a list of 21 stars that we think are most suitable candidates for a detailed study with the Doppler-imaging technique.

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Photometric Modelling of Starspots II. The FORTRAN Code SPOTPIC

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A FORTRAN code which computes synthetic light and colour curves of active, spotted stars has been developed. The main feature of this code is its ability to model simultaneously the V light curve and the $(V{-}R)_c$, $(V{-}I)_c$ and $(V{-}K)$ colour data. It also uses new effective temperature-colour and Barnes-Evans-like calibrations, temperature and gravity-dependent limb-darkening coefficients and different effective surface gravities for the spotted and unspotted photosphere. The code allows for two-component spots, i.e., spots with umbral and penumbral components. Various problematic spot configurations were investigated, taking us to the conclusion that, in order to be able to differentiate spots with various thermal structures (umbrae, penumbrae, faculae) or polar spots from equatorial bands, the modelling of the infrared colours, especially $(V{-}I)_c$ and $(V{-}K)$, is needed.

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The APM Survey for Cool Carbon Stars in the Galactic Halo - II. The Search for Dwarf Carbon Stars

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We present proper motion measurements for carbon stars found during the APM Survey for Cool Carbon Stars in the Galactic Halo (Totten & Irwin, 1998). Measurements are obtained using a combination of POSSI, POSSII and UKST survey plates supplemented where necessary by CCD frames taken at the Isaac Newton Telescope. We find no significant proper motion for any of the new APM colour-selected carbon stars and so conclude that there are no dwarf carbon stars present within this sample. We also present proper motion measurements for three previously known dwarf carbon stars and demonstrate that these measurements agree favourably with those previously quoted in the literature, verifying our method of determining proper motions. Results from a complimentary program of JHK photometry obtained at the South African Astronomical Observatory are also presented. Dwarf carbon stars are believed to have anomalous near-infrared colours, and this feature is used for further investigation of the nature of the APM carbon stars. Our results support the use of JHK photomtery as a dwarf/giant discriminator and also reinforce the conclusion that none of the new APM-selected carbon stars are dwarfs. Finally, proper motion measurements combined with extant JHK photometry are presented for a sample of previously known Halo carbon stars, suggesting that one of these stars, CLS29, is likely to be a previously unrecognised dwarf carbon star.

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Absolute Dimensions of Eclipsing Binaries. XXIII. The F-type System EI Cephei

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We report new radial velocity measurements made with the CfA Digital Speedometers of the F-type double-lined eclipsing binary EI Cep (P = 8.4 days), in which the secondary is a metallic-line star. Using these and previous measurements from the literature, we redetermine the masses of the components to a precision of 0.4%, 4 to 5 times better than previously achieved. We also reanalyze UBV light curves for the system from the literature with modern methods to determine the radii and the effective temperatures. The resulting stellar parameters are $M_A = 1.7716 \pm 0.0066\,\mathrm{M}_\odot$, $M_B = 1.6801 \pm 0.0062\,\mathrm{M}_\odot$, $R_A = 2.896 \pm 0.048\,\mathrm{R}_\odot$, $R_B = 2.329 \pm 0.044\,\mathrm{R}_\odot$, $T_{\rm eff}^A = 6750 \pm 100\,\mathrm{K}$,

and $T_{\rm eff}^B = 6950 \pm 100$ K. Further properties of the system are given in Table 6. Both components are near the end of their main-sequence evolution, and a comparison of the observational results with theoretical evolutionary models gives excellent agreement with models using two somewhat different treatments of overshooting from the convective cores (but not with standard models). An age of 1.4 Gyr is derived for the roughly solar metallicity indicated by our low-S/N spectra. A precise spectroscopic determination of the metallicity of EI Cep would be very useful to place even tighter constraints on the models. The measured projected rotational velocities of the stars (13 km s^{-1} and 17 km s^{-1} for EI Cep A and B) are very close to but not quite synchronized with the orbital motion. This is in agreement with predictions from current tidal theories which, however, also predict that orbital circularization has not yet occurred, although we detect no significant eccentricity.

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HST Observations of M Subdwarfs

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We present the results of an HST snapshot program to search for very-low-mass stellar companions to nearby M subdwarfs. None of our nine targetted metal-poor primaries have companions more massive than the hydrogen burning limit, implying that the halo binary fraction is equal to or less than the Galactic disk binary fraction below $0.3 M_\odot$. In addition, the more distant tertiary VB12, an sdM3.0 companion to an F subdwarf double, is also unresolved. We show that the relation between WFPC2 F555W and F850LP photometry and ground V,I photometry is consistent with theoretical expectations. We also report that two recently observed Hyades M dwarfs appear single.

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Spectral Energy Distributions for M–Dwarfs

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We have obtained infrared (1—2.5μm) spectroscopy for 42 halo and disk dwarfs with spectral type M1 to M6.5. These data are compared to synthetic spectra generated by the latest model atmospheres of Allard & Hauschildt. Photospheric parameters metallicity, effective temperature and radius are determined for the sample. We find good agreement between observation and theory except for known problems due to incomplete molecular data for metal hydrides and H_2O. The metal–poor M subdwarfs are well matched by the models as oxide opacity sources are less important in this case. The derived effective temperatures for the sample range from 3600 K to 2600 K; at these temperatures grain formation and extinction are not significant in the photosphere. The derived metallicities range from solar to one-tenth solar. The radii and effective temperatures derived agree well with recent models of low mass stars.

The spectra are available in electronic form, on request.

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Dynamo Action and Period Gap in Cataclysmic Variables

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The conjecture is presented that the gap in the distribution of the orbital periods of cataclysmic variables is related to a particular kind of hydromagnetic dynamo, called interface dynamo, operating near the base of the convective envelope of their secondary components. Such a dynamo is characterized by the spatial separation of the regions where the differential rotation and the α-effect operate. Unlike conventional dynamos, its linear growth rate becomes negative for highly supercritical dynamo numbers, leading to the disappearance of the dynamo action. If such a result from the linear theory will be confirmed by non-linear calculations, it may provide a physical basis to the so-called disrupted magnetic braking hypothesis, invoked to explain the existence of the period gap by several evolutionary models of the cataclysmic variables.

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An X-ray Flare Detected on the M8 dwarf VB 10

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We have detected an X-ray flare on the very low mass star VB 10 (GL 752 B; M8 V) using the ROSAT High Resolution Imager. VB 10 is the latest type (lowest mass) main sequence star known to exhibit coronal activity. X-rays were detected from the star during a single 1.1-ksec segment of an observation which lasted 22 ksec in total. The energy released by this flare is on the order of 10^{27} ergs s^{-1}. This is at least two orders of magnitude greater than the quiescent X-ray luminosity of VB 10, which has yet to be measured. This X-ray flare is very similar in nature to the far ultraviolet flare which was observed by Linsky et al. (1995) using the Goddard High Resolution Spectrograph onboard the Hubble Space Telescope. We discuss reasons for the extreme difference between the flare and quiescent X-ray luminosities, including the possibility that VB 10 has no quiescent (10^6 K) coronal plasma at all.

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The Near-Ultraviolet Continuum of Late-Type Stars

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Analyses of the near-ultraviolet continuum of late-type stars have led to controversial results regarding the performance of state-of-the-art model atmospheres. The release of the homogeneous IUE final archive and the availability of the high-accuracy *Hipparcos* parallaxes provide an opportunity to revisit this issue, as accurate stellar distances make it possible to compare observed absolute fluxes with the predictions of model atmospheres.

The near-UV continuum is highly sensitive to $T_{\rm eff}$ and [Fe/H], and once the gravity is constrained from the parallax, these parameters may be derived from the analysis of low-dispersion *long-wavelength* (2000–3000 Å) IUE spectra for stars previously studied by Alonso et al. (1996; A&AS 117, 227) using the Infrared Flux Method (IRFM). A second comparison is carried out against the stars spectroscopically investigated by Gratton et al. (1996; A&A 314, 191). It is shown that there is a good agreement between $T_{\rm eff}$s obtained from the IRFM and from the near-UV continuum, and a remarkable correspondence between observed and synthetic fluxes for stars with $4000 \leq T_{\rm eff} \leq 6000$ K of any metallicity and gravity. These facts suggest that model atmospheres provide an adequate description of the near-UV continuum forming region and that the opacities involved are essentially understood. For cooler stars, the results of

the IRFM are no longer reliable, as shown by Alonso et al., but the discrepancy noticed for stars hotter than 6000 K may reflect problems in the model atmospheres and/or the opacities at these higher temperatures.

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Solar Abstracts

Particle Acceleration in Reconnecting Current Sheets in Impulsive Electron-Rich Solar Flares

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Electron and proton acceleration in reconnecting current sheets in electron-rich solar flares is considered. A significant three-dimensional magnetic field is assumed in the current sheet where the particles are accelerated by the DC electric field. The tearing instability of a pre-flare current sheet leads to the formation of multiple singular lines of magnetic field where the electric and magnetic fields are coaligned. Magnetized electrons are shown to be accelerated to a few tens of MeV before they leave the vicinity of a singular line. The acceleration time is estimated to be less than 10^{-3} s. By contrast, much heavier protons are unmagnetized and their energy gain is more modest. The model explains a high electron to proton ratio and the unusually intense gamma-ray continuum above 1 MeV observed in the electron-rich flares.

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On the Nature of the “Moss” Observed by TRACE

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Moss is the name given to low lying ($\sim$ 3000 km), hot ($\sim$ 1 MK) solar coronal plasma that has recently been observed by the Transition Region and Coronal Explorer (TRACE). This paper investigates two hypotheses regarding the nature of the moss: (1) emission from small, million degree loops; (2) emission from the legs of 3-10 million degree loops. We update the coronal radiative loss curve, using the most recent results for coronal abundances, and use an analytical loop model to find that the first hypothesis requires a filling factor close to unity to reproduce the observed emission measure, while the second hypothesis results in a filling factor of about 0.1, in agreement with other independent multi-wavelength analyses of moss. We find that the vertical extent and the height of the moss layer above the limb are also very well reproduced with the second hypothesis. We further show that the observed brightness of the moss scales linearly with the loop pressure and filling factor, independent of the loop length, and we derive a general expression for the conversion factor.

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Homologous Sudden Disappearances of Transequatorial Interconnecting Loops in the Solar Corona

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We have found a remarkable sequence of homologous *disappearances* of transequatorial X-ray loops linking active regions. Each disappearance was closely associated with a major flare and coronal mass ejection (CME). In each case the flarings precede the disappearances and the CMEs. Mass estimates for the X-ray loops are similar to CME masses. This, the timing of the disappearances, their morphology, and the homology of the events in the sequence, provide direct evidence for a new class of CME origins in the low corona. We also briefly report observations of features which we infer to be the soft X-ray counterparts of shock waves emanating from the flare region. The inferred shocks appeared to play a vital role in the disappearances. Our results suggest that flare-generated shock waves may destabilize large transequatorial loops, causing them to erupt.

Accepted by GRL

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Giant Macro-spicule as Observed by CDS on SOHO

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We examine spectral time series of coronal line Mg IX 368 Å and transition region line O V 629 Å, observed with the Coronal Diagnostic Spectrometer (CDS) onboard the SOHO spacecraft. Primarily we were looking for intensity and velocity oscillations in polar plumes, however by chance we detected a giant macro-spicule at the limb and were able to follow its dynamical structure. Blue and red-shifted emission in the O V line indicates that it is probably a rotating twisted magnetic jet. Emission is also detected in the Mg IX 368 Å line, at a temperature of 1 million K.

Both Fourier and wavelet transforms have been applied independently to the analysis of the oscillations in order to find the most reliable periods. We report here on the existence of long period oscillations in the polar plumes as observed in the O V 629 Å line. Our observations indicate the presence of compressional waves with periods of 20-25 minutes.

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Cyclic Behaviour of Sunspot Activity During the Maunder Minimum

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We study the behaviour of sunspot activity in 1610-1750, i.e. just prior to, during and slightly after the Maunder minimum, using the new series of group sunspot numbers. We apply the delayed component technique and show that, while the transition from the normal cyclic evolution to the minimum was very abrupt, the recovery from the minimum was gradual, proceeding through a tiny but very regular cycle in 1700-1712 and a transition period with a phase catastrophe in 1712-1720. Exploiting the good coverage of the Maunder minimum by daily solar observations, we show that the sunspot ocurrence is concentrated, with a high statistical significance, to two intervals around 1658 and 1680. Together with the last sunspot maximum before the Maunder minimum in 1639/1640, and the maximum in 1705, this implies a significant, approximately 22-year periodicity in sunspot activity during the Maunder minimum.

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Simultaneous *SOHO* and *Yohkoh* Observations of a Small Solar Active Region

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We present new results from observations of a small active region taken with the SUMER spectrograph and Extreme Ultraviolet Imaging Telescope (EIT) on *SOHO*, and the Soft X-ray Telescope (SXT) on *Yohkoh*. The SUMER study features line and continuum emission covering a wide range of temperatures, and includes the density-sensitive O IV] λ1400 multiplet. A more extensive analysis of quiet Sun data presented in a previous paper is also included. The presence of a power-law relationship between emission line power and electron density is confirmed, although the exponents in the active region are slightly higher than those found in the quiet Sun. These power-law relationships suggest that the volume filling factor decreases with increasing density, and indicate possible differences between emitting material in active regions and the quiet Sun. We study active region emission measures from both the SUMER and SXT data sets. For the active region as a whole, SXT temperatures and emission measures appear to fit smoothly onto the emission measure distribution determined from cooler transition region and coronal lines in the SUMER spectra. We find no significant variation in the shape of the lower transition region emission measure distribution for different subregions of the data set. This reinforces the conclusion from the original quiet Sun paper that ensembles of "cool loops" are unlikely to be the source of this emission unless the structures are considerably smaller than the 1$''$ spatial resolution of SUMER.

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The CO Fundamental Vibration-Rotation Lines in the Solar Spectrum: II. Non-LTE Transfer Modeling in Static and Dynamic Atmospheres

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A numerical method is presented to solve radiative transfer in molecular vibration-rotation bands which allows for departures from Local Thermodynamic Equilibrium (LTE) while accurately including a large number of lines. The method is applied to the formation of the CO fundamental vibration-rotation bands in several plane-parallel hydrostatic models, and in a sequence of 20 snapshots from a radiation-hydrodynamics simulation of chromospheric dynamics by Carlsson & Stein. Calculations for the hydrostatic models performed with different values of the collisional coupling between different vibrational states confirm earlier results by Ayres & Wiedemann showing that the CO lines have LTE source functions in the solar atmosphere, so that emergent CO intensities reflect actual temperatures therein. Only if the canonical collisional strengths are too large by more than two orders of magnitude, would it be possible to explain the low temperatures derived from CO line core intensities at the solar limb by scattering in an atmosphere with much higher temperatures, consistent with the values derived from UV line and continuum and Ca II resonance line diagnostics. An interesting feature in the wavelength structure of the CO vibration-rotation bands is pointed out by which pairs of lines can be found in different bands but of similar strength *and* wavelength. In principle such pairs provide a diagnostic for departures from LTE in the CO lines.

CO line core intensity variations computed from the sequence of dynamical snapshots, which represent a typical episode in the chromospheric dynamics simulation, have an amplitude that is 2.5 times higher than observed. It is shown that this large amplitude is in part due to the up and down shift of the CO line formation region during the evolution of the atmosphere, and is related to the assumption of instantaneous chemical equilibrium that was assumed to calculate CO concentrations. This suggests that the CO concentration is not in equilibrium, and may be lower than would be expected on the basis of chemical equilibrium at the time-averaged mean temperature of the atmosphere, and may

have reduced variations compared to instantaneous chemical equilibrium values at the local temperatures.

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ANNOUNCEMENT

Upcoming Observing Campaign (AD Leo)

AD LEO FLARE CAMPAIGN PLANNED FOR 10-13 MARCH 2000 (UT)

A major campaign to monitor the dMe flare star AD Leo is set for the second week of March, 2000. Observations anytime during the period 10 March 2000 0h UT through 13 March 2000 23h UT will be useful. We particularly need high time resolution U-band photometry, although any other observations are also welcome. The current observing complement includes the FUSE, EUVE and HST/STIS satellites, high resolution optical spectroscopy and photometry at McDonald Observatory and low resolution spectroscopy at the Dominion Astrophysical Observatory. Those who contribute data that are eventually used in the publications will be included as authors. Please contact Suzanne Hawley for more details.

Submitted by: Suzanne Hawley, University of Washington (slh@astro.washington.edu)

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

`http://casa.colorado.edu/~skinners/coolnews.html` .