COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

A White Light Megaflare on the dM4.5e Star YZ CMi

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On UT 2009 January 16, we observed a white light megaflare on the dM4.5e star YZ CMi as part of a long-term spectroscopic flare-monitoring campaign to constrain the spectral shape of optical flare continuum emission. Simultaneous U-band photometric and 3350-9260Å spectroscopic observations were obtained during 1.3 hours of the flare decay. The event persisted for more than 7 hours and at flare peak, the U-band flux was almost 6 magnitudes brighter than in the quiescent state. The properties of this flare mark it as one of the most energetic and longest-lasting white light flares ever to be observed on an isolated low-mass star. We present the U-band flare energetics and a flare continuum analysis. For the first time, we show convincingly with spectra that the shape of the blue continuum from 3350Å to 4800Å can be represented as a sum of two components: a Balmer continuum as predicted by the Allred et al radiative hydrodynamic flare models and a T ∼10,000K blackbody emission component as suggested by many previous studies of the broadband colors and spectral distributions of flares. The areal coverage of the Balmer continuum and blackbody emission regions vary during the flare decay, with the Balmer continuum emitting region always being significantly (∼3-16 times) larger. These data will provide critical constraints for understanding the physics underlying the mysterious blue continuum radiation in stellar flares.

Accepted by ApJ Letters

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For preprints via WWW: http://www.astro.washington.edu/kowalski/yzcmi_apjl.pdf

Sloan Low-mass Wide Pairs of Kinematically Equivalent Stars (SLoWPoKES): A Catalog of Very Wide, Low-mass Pairs

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We present the Sloan Low-mass Wide Pairs of Kinematically Equivalent Stars (SLoWPoKES), a catalog of 1342 very-wide (projected separation >500 AU), low-mass (at least one mid-K – mid-M dwarf component) common proper motion pairs identified from astrometry, photometry, and proper motions in the Sloan Digital Sky Survey. A Monte Carlo based Galactic model is constructed to assess the probability of chance alignment for each pair; only pairs with a probability of chance alignment ≤ 0.05 are included in the catalog. The overall fidelity of the catalog is expected to be 98.35%. The selection algorithm is purposely exclusive to ensure that the resulting catalog is efficient for follow-up studies of low-mass pairs. The SLoWPoKES catalog is the largest sample of wide, low-mass pairs to date and is intended as an ongoing community resource for detailed study of *bona fide* systems. Here we summarize the general characteristics of the SLoWPoKES sample and present preliminary results describing the properties of wide, low-mass pairs. While the majority of the identified pairs are disk dwarfs, there are 70 halo subdwarf pairs and 21 white dwarf–disk dwarf pairs, as well as four triples. Most SLoWPoKES pairs violate the previously defined empirical limits for maximum angular separation or binding energies. However, they are well within the theoretical limits and should prove very useful in putting firm constraints on the maximum size of binary systems and on different formation scenarios. We find a lower limit to the wide binary frequency for the mid-K – mid-M spectral types that constitute our sample to be 1.1%. This frequency decreases as a function of Galactic height, indicating a time evolution of the wide binary frequency. In addition, the semi-major axes of the SLoWPoKES systems exhibit a distinctly bimodal distribution, with a break at separations around 0.1 pc that is also manifested in the system binding energy. Comparing with theoretical predictions for the disruption of binary systems with time, we conclude that the SLoWPoKES sample comprises two populations of wide binaries: an "old" population of tightly bound systems, and a "young" population of weakly bound systems that will not survive more than a few Gyr. The SLoWPoKES catalog and future ancillary data are publicly available on the world wide web for utilization by the astronomy community.

Accepted by AJ

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The Luminosity and Mass Functions of Low–Mass Stars in the Galactic Disk: II. The Field

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We report on new measurements of the luminosity function (LF) and mass function (MF) of field low–mass dwarfs derived from Sloan Digital Sky Survey (SDSS) Data Release 6 (DR6) photometry. The analysis incorporates ∼ 15 million low–mass stars ($0.1\ \mathcal{M}_{\odot} < \mathcal{M} < 0.8\mathcal{M}_{\odot}$), spread over 8,400 square degrees. Stellar distances are estimated using new photometric parallax relations, constructed from *ugriz* photometry of nearby low–mass stars with trigonometric parallaxes. We use a technique that simultaneously measures Galactic structure and the stellar LF from $7 < M_r < 16$. We compare the LF to previous studies and convert to a MF using the mass–luminosity relations 2000, A&A, 364, 217. The system MF, measured over $-1.0 < \log \mathcal{M}/\mathcal{M}_{\odot} < -0.1$, is well–described by a log–normal distribution with $\mathcal{M}_{\circ} = 0.25\ \mathcal{M}_{\odot}$. We stress that our results should not be extrapolated to other mass regimes. Our work generally

agrees with prior low–mass stellar MFs and places strong constraints in future star–formation studies of the Milky Way.

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Chromospheric Activity Among Fast Rotating M-dwarfs in the Open Cluster NGC 2516

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We report radial velocities (RVs), projected equatorial velocities ($v \sin i$) and Ca II triplet (CaT) chromospheric activity indices for 237 late-K to mid-M candidate members of the young open cluster NGC 2516. These stars have published rotation periods between 0.1 and 15 days. Intermediate resolution spectra were obtained using the Giraffe spectrograph at the Very Large Telescope. Membership was confirmed on the basis of their RVs for 210 targets. For these stars we see a marked increase in the fraction of rapidly rotators as we move to cooler spectral types. About 20 per cent of M0–M1 stars have $v \sin i > 15\,\mathrm{km\,s^{-1}}$, increasing to 90 per cent of M4 stars. Activity indices derived from the first two lines of the CaT (8498Å and 8542Å) show differing dependencies on rotation period and mass for stars lying above and below the fully convective boundary. Higher mass stars, of spectral type K3–M2.5, show chromospheric activity which increases with decreasing Rossby number (the ratio of period to convective turnover time), saturating for Rossby numbers < 0.1. For cooler stars, which are probably fully convective and almost all of which have Rossby numbers < 0.1, there is a clear decrease in chromospheric activity as $(V-I)_0$ increases, amounting to a fall of about a factor of 2–3 between spectral types M2.5 and M4. This decrease in activity levels at low Rossby numbers is not seen in X-ray observations of the coronae of cluster M-dwarfs or of active field M-dwarfs. There is no evidence for supersaturation of chromospheric activity for stars of any spectral type at Rossby numbers < 0.01. We suggest that the fall in the limiting level of chromospheric emission beyond spectral type M3 in NGC 2516 is, like the simultaneous increase in rotation rates in field stars, associated with a change in the global magnetic topology as stars approach the fully convective boundary and not due to any decrease in dynamo-generated magnetic flux.

and the name of journal, for example: Accepted by MNRAS

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Observation and Modelling of Main Sequence Stellar Chromospheres; XIV Rotation of dM1 Stars

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We have measured vsini for a selected sample of dM1 type stars. We give 114 measurements of vsini for 88 different stars, and 6 upper detection limits. These are the first measurements of vsini for most of the stars studied here. This represents the largest sample of vsini measurements for M dwarfs at a given spectral type. For these measurements, we used four different spectrographs: HARPS (ESO), SOPHIE (OHP), ÉLODIE (OHP), ans UVES (ESO). Two of these spectrographs (HARPS, SOPHIE) are particularly stable in wavelength since they were designed for exoplanet searches.

We measured vsini down to an accuracy of 0.3 $km\ s^{-1}$ for the highest resolution spectrographs and a detection limit of about 1 $km\ s^{-1}$. We show that this unprecedented accuracy for M dwarfs is possible only if all the targets have the same spectral type. These values were combined with other measurements taken from the literature. The total sample represents detected rotation for 100 stars (10 dM1e stars and 90 dM1 stars). We confirm our finding of Paper VII that the distribution of the projected rotation period is bimodal for dM1 stars with a much larger sample, i.e., there are two groups of stars: the fast rotators with P/sini$\sim$ 4.5 days and the slow rotators with P/sini$\sim$14.4 days. There is a gap between these two groups. We find that the distribution of stars as a function of P/sini has two very abrupt cuts, below 10 days and above 18 days. There are very few stars observed out of this range 10-18 days. W also

observe that the distribution increases slightly from 18 days to 10 days.

We find that the M1 subdwarfs (sdM1; very low metallicity dwarfs) rotate faster with an average period of P/sini∼7.2 days, about twice faster as the main group of normal M1 dwarfs. We also find a correlation for P/sini to decrease with stellar radius among dM1e stars. There is also such a trend observed in dM1 stars.

We also derive metallicity and radius for all our target stars using the same method as in Paper VII. We notably found that 11 of our target stars are subdwarfs with metallicities below -0.5 dex.

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Photospheric and Chromospheric Activity on the Young Solar-type Star HD 171488 (V889 Herculis)

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We present the results of contemporaneous spectroscopic and photometric monitoring of the young solar-type star HD 171488 ($P_{\rm rot} \simeq 1.337$ days) aimed at studying surface inhomogeneities at both photospheric and chromospheric levels. Echelle FOCES spectra ($R \simeq 40\,000$) and Johnson BV photometry have been performed in August 2006, with a good coverage of rotational phases. Spectral type, rotational velocity, metallicity, and gravity were determined using a code developed by us (ROTFIT) and a library of spectra at the same resolution of slowly-rotating reference stars. The metallicity was measured from the analysis of iron lines with the MOOG code. The spectral subtraction technique was applied to the most relevant chromospheric diagnostics included in the FOCES spectral range, namely Ca II IRT, Hα, He I D_3, Hβ, and CaII H&K lines. A simple model with two large high-latitude spots is sufficient to reproduce the B and V light curves as well the radial velocity modulation, if a temperature difference between photosphere and spots of about 1500 K is used. A Doppler imaging analysis of photospheric lines basically confirms a similar spot distribution. With the help of an analogous geometric two-spot model, we are able to reproduce the observed modulations in the residual chromospheric emissions adopting different values of ratios between the flux of plages and quiet chromosphere (about 5 for Hα and 3 for Ca II diagnostics). Facular regions of solar type appear to be the main responsible for the modulations of chromospheric diagnostics. Both the spot/plage model and the cross-correlation between the light curve and the chromospheric line fluxes display a sensible lead effect of plages with respect to spots (from 20° to 40° in longitude), as already observed in some active solar-type stars and RS CVn systems. The contemporaneous monitoring of photospheric and chromospheric diagnostics in the young and rapidly rotating solar-type star HD 171488 allowed us to detect active regions which have nearly the same location at both atmospheric layers, with plages slightly leading spots in longitudes. These active regions are similar to the solar ones in some respect, because the spot temperature is close to that of sunspot umbrae and the plage flux-contrast is consistent with the average solar values. The main differences with respect to the Sun are larger sizes and higher latitudes.

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Soft X-ray Coronal Spectra at Low Activity Levels Observed by RESIK

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The quiet-Sun X-ray emission is important for deducing coronal heating mechanisms, but it has not been studied in detail since the emphOrbiting Solar Observatory (*OSO*) spacecraft era. Bragg crystal spectrometer X-ray observations have generally concentrated on flares and active regions. The high sensitivity of the RESIK (REntgenovsky Spectrometer s Izognutymi Kristalami) instrument on the *CORONAS-F* solar mission has enabled the X-ray emission from the quiet corona to be studied in a systematic way for the first time. Our aim is to deduce the physical conditions of the non-flaring corona from RESIK line intensities in several spectral ranges using both isothermal and multithermal assumptions. We selected and analyzed spectra in 312 quiet-Sun intervals in January and February 2003, sorting them into 5 groups according to activity level. For each group, the fluxes in selected spectral bands have been used to calculate values parameters for the best-fit that lead to a intensities characteristic of each group. We used both isothermal and multitemperature assumptions, the latter described by differential emission measure (DEM) distributions. RESIK spectra cover the wavelength range ($3.3 - 6.1$ Å). This includes emission lines of highly ionized Si, S, Cl, Ar, and K, which are suitable for evaluating temperature and emission measure, were used. The RESIK spectra during these intervals of very low solar activity for the first time provide information on the temperature structure of the quiet corona. Although most of the emission seems to arise from plasma with a temperature between 2 MK and 3 MK, there is also evidence of a hotter plasma ($T \sim 10$ MK) with an emission measure 3 orders smaller than the cooler component. Neither coronal nor photospheric element abundances appear to describe the observed spectra satisfactorily. Accepted by A&A *For preprints contact*: bs@cbk.pan.wroc.pl *For preprints via WWW*: http://www.cbk.pan.wroc.pl/js/QUIET_AA_Paper/

Physics of the Solar Cycle: New Views

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Presently there are two schools of thought viz., turbulent dynamo and MHD oscillation mechanisms that explain the solar cycle and activity phenomena. Both the mechanisms are critically examined and fundamental difficulties are presented. By keeping in mind the more advantages of having MHD oscillation mechanism, compared to the turbulent dynamo mechanism, the following new ideas on the genesis of the solar cycle and activity phenomena are presented. The inevitability of the most likely existence of a combined poloidal and toroidal magnetic field structure in the solar interior is proposed. Owing to the suitable poloidal part of the steady field structure, the Alfven wave perturbations of long periods ($\sim$ 22 years) that excite in the solar core travel first to the poles in both the hemispheres and later reach the equator. While traveling towards the surface, the Alfven wave perturbations along the weak poloidal field structure in turn perturb the embedded strong toroidal field structure producing sunspots, especially in the convective envelope, that travel to the surface due to buoyancy along isorotational contours. With a realistic density structure of the solar interior, the computation of Alfven wave travel times along different field lines of the poloidal field structure [Hiremath and Gokhale, ApJ, 448, 437, 1995] yields almost similar periods ($\sim$ 22 yr) explaining the constancy of 22 yr periodicity of the odd degree modes obtained from the Spherical Harmonic Fourier analysis of the surface magnetic field. The observed quasi-periodicities of solar activity indices in the range of 1-5 years are explained as due to the Alfven wave perturbation of the strong toroidal field structure. The variation of the long period solar cycle and activity phenomena such as the Maunder and the grand minima is explained to be due to the coupling of long period poloidal and toroidal MHD oscillations.
Accepted by: Sun and Geosphere

The SECIS instrument on the Lomnický Peak Observatory

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Heating mechanisms of the solar corona will be investigated at the high-altitude solar observatory Lomnicky Peak of the Astronomical Institute of SAS (Slovakia) using its mid-size Lyot coronagraph and post-focal instrument SECIS provided by Astronomical Institute of the University of Wrocław (Poland). The data will be studied with respect to the energy transport and release responsible for heating the solar corona to temperatures of mega-Kelvins. In particular investigations will be focused on detection of possible high-frequency MHD waves in the solar corona. The scientific background of the project, technical details of the SECIS system modified specially for the Lomnicky Peak coronagraph, and inspection of the test data are described in the paper. Accepted by Contributions to the Astronomical Observatory of Skalneté Pleso *For preprints contact*: ambroz@astro.sk

Periodicities in Solar Flare Index Cycles of 21 - 23: Revisited

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The periodic analyses of solar flare data have been carried out by different authors for about three decades. Controversial results appear as depending on the analysis techniques and investigated time periods. Considering that different authors applied different methods to different data sets, it seems necessary to reanalyze the periodicity of solar flare index with a unified method. In this study we used two new methods to investigate the periodic behavior of solar flare index data, first for individual cycles 21, 22 and 23, and then for all of them. We used (i) the multi taper method with red and white noise approximations, and (ii) the Morlet wavelet transform for periodicity analysis. Apart from the solar rotation periodicity of about 27 days which is of obvious significance and is found in all examined cycles with at least a 90% significance level, we obtained the following prominent periods: 152 days for cycle 21, 73 days for cycle 22, and 62 days for cycle 23. Finally, we compare our results with the ones previously found. We emphasize the fact that a lesser number of periodicities is found in the range of low frequencies (long periods) while the higher frequencies show a greater number of periodicities. This result might be useful for better predictions of the solar cycles.

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A Nearby Young Brown Dwarf Binary Candidate

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In near-infrared NaCo observations of the young brown dwarf 2MASS J0041353-562112, we discovered a companion a little less than a magnitude fainter than the primary. The binary candidate has a separation of 143 mas, and the spectral types of the two components are M6.5 and M9.0. Colors and flux ratios of the components are consistent with their locations being at the same distance minimizing the probability of the secondary being a background object. The brown dwarf is known to exhibit Li absorption constraining the age to be younger than ~ 200 Myr, and has been suspected of experiencing ongoing accretion, which implies an age as young as ~ 10 Myr. We estimate distance and orbital parameters of the binary as a function of age. For an age of 10 Myr, the distance to the system is 50 pc, the orbital period is 126 yr, and the masses of the components are ~ 30 and $\sim 15\,M_{Jup}$. The binary brown dwarf fills a so far unoccupied region in the parameters mass and age; it is a valuable new benchmark object for brown dwarf atmospheric and evolutionary models.

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On the Kinematic Age of Brown Dwarfs: Radial Velocities and Space Motions of 43 Nearby L Dwarfs

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We present radial velocity measurements of a sample of L0–L8 dwarfs observed with VLT/UVES and Keck/HIRES. We combine these measurements with distance and proper motion from the literature to determine space motions for 43 of our targets. We identify nine candidate members of young moving groups, which have ages of 50–600 Myr according to their space motion. From the total velocity dispersion of the 43 L dwarfs, we calculate a kinematic age of ∼5 Gyr for our sample. This age is significantly higher than the ∼3 Gyr age known for late M dwarfs in the solar neighbourhood. We find that the distributions of the U and V velocity components of our sample are clearly non-Gaussian, placing the age estimate inferred from the full space motion vector into question. The W-component exhibits a distribution more consistent with a normal distribution, and from W alone we derive an age of ∼3 Gyr, which is the same age found for late-M dwarf samples. Our brightness-limited sample is probably contaminated by a number of outliers that predominantly bias the U and V velocity components. The origin of the outliers remain unclear, but we suggest that these brown dwarfs may have gained their high velocities by means of ejection from multiple systems during their formation.

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Cross-Listed Abstracts (Pre-Main Sequence Stars)

Editor's Note: The abstracts below are being cross-listed with the *Star Formation Newsletter.*

Results from DROXO. III. Observation, Source List and X-ray Properties of Sources Detected in the "Deep Rho Ophiuchi XMM-Newton Observation"

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X-rays from very young stars are powerful probes to investigate the mechanisms at work in the very first stages of the star formation and the origin of X-ray emission in very young stars. We present results from a 500 ks long observation of the Rho Ophiuchi cloud with a XMM-Newton large program named DROXO, aiming at studying the X-ray emission of deeply embedded Young Stellar Objects (YSOs). The data acquired during the DROXO program were reduced with SAS software, and filtered in time and energy to improve the signal to noise of detected sources; light curves and spectra were obtained. We detected 111 sources, 61 of them associated with ρ Ophiuchi YSOs as identified from infrared observations with ISOCAM. Specifically, we detected 9 out of 11 Class I, 31 out of 48 Class II and 15 out 16 Class III objects. Six objects out of 21 classified Class III candidates are also detected. At the same time we suggest that 15 Class III candidates that remain undetected at $\log L_{\rm X}\,[{\rm erg/s}] < 28.3$ are not related to the cloud population. The global detection rate is $\sim 64\%$. We have achieved a flux sensitivity of $\sim 5 \cdot 10^{-15}$ erg s^{-1} cm^{-2}. The $L_{\rm X}/L_{rmbol}$ ratio shows saturation at a value of ~ -3.5 for stars with $T_{\rm eff} \leq 5000$ K or 0.7 M$\odot$ as observed in the Orion Nebula. The plasma temperatures and the spectrum absorption show a decline with YSO class, with Class I YSOs being hotter and more absorbed than Class II and III YSOs. In one star (GY 266) with infrared counterpart in 2MASS and Spitzer catalogs we have detected a soft excess in the X-ray spectrum which is best fitted by a cold thermal component less absorbed than the main thermal component of the plasma. Such a soft component hints to the presence of plasma heated by shocks due to jets outside the dense circumstellar material.

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Review Article Abstracts

The Solar Cycle

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The Solar Cycle is reviewed. The 11-year cycle of solar activity is characterized by the rise and fall in the numbers and surface area of sunspots. We examine a number of other solar activity indicators including the 10.7 cm radio flux, the total solar irradiance, the magnetic field, flares and coronal mass ejections, geomagnetic activity, galactic cosmic ray fluxes, and radioisotopes in tree rings and ice cores that vary in association with the sunspots. We examine the characteristics of individual solar cycles including their maxima and minima, cycle periods and amplitudes, cycle shape, and the nature of active latitudes, hemispheres, and longitudes. We examine long-term variability including the Maunder Minimum, the Gleissberg Cycle, and the Gnevyshev-Ohl Rule. Short-term variability includes the 154-day periodicity, quasi-biennial variations, and double peaked maxima. We conclude with an examination of prediction techniques for the solar cycle.

Published by: Living Reviews in Solar Physics, 7, 2010

For article via WWW: http://www.livingreviews.org/lrsp-2010-1

Upcoming Meeting

The 15th Annual ADAS Workshop

3 - 5 October 2010

Armagh Observatory (N. Ireland)

The 15th annual ADAS Workshop will take place at Armagh Observatory 3 - 5 October 2010. ADAS (Atomic Data and Analysis Structure) is an interconnected set of computer codes and data collections for modelling the radiating properties of ions and atoms in plasmas. It can address plasmas ranging from the interstellar medium through to the solar atmosphere and laboratory thermonuclear fusion devices to technological plasmas and can assist in the analysis and interpretation of spectral emission and supports detailed plasma models. The primary topics in this years workshop include Spectral diagnostic advances, lifting the quality of atomic data, plus atomic and plasma models in fusion and astrophysics.

Full information about the workshop will be posted on the ADAS website at:

http://www.adas.ac.uk/workshop2010.php

Abstract Guidelines

Abstracts for *COOLNEWS* are solicited for papers that have been recently accepted by or submitted to refereed journals, and for recent Ph.D. theses. Abstracts for conference proceedings articles are *not* posted in *COOLNEWS*. The subject matter should pertain directly to cool stars (spectral types F,G,K,M or L), substellar objects, or the sun. Both theoretical and observational abstracts are appropriate.

Abstracts dealing with cool pre-main-sequence (PMS) stars will generally not be included in *COOLNEWS*, since they are already covered by the *Star Formation Newsletter*. Exceptions to this rule will be considered if the subject matter is truly cross-disciplinary. If you wish to submit a cross-disciplinary abstract on PMS stars, then first submit it to the *Star Formation Newsletter*. After doing so, submit the abstract to *COOLNEWS* accompanied by a short e-mail stating that it has already been submitted to the *Star Formation Newsletter*, and summarizing why it will be of interest to the cool star/solar community at large.

A monthly call for abstracts will be issued and abstracts received by the last day of the month will usually appear in the following month's newsletter. Announcements of general interest to the cool star and solar communities may also be submitted for posting in the newsletter. These might include (but are not restricted to) the following: (i) *Job Openings* directed toward cool star or solar researchers, (ii) announcements of *Upcoming Meetings*, (iii) announcements of *Upcoming Observing Campaigns* for which participation is solicited from the community at large, (iv) reviews of *New Books*, and (v) *General Announcements* that provide or request research-related information. Please send all correspondence to the editor at coolnews@jila.colorado.edu. Abstract templates and back issues can be obtained from the COOLNEWS Web-page at

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

*** Please send abstracts in the body of the message and *not* as attachments.***