COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 29 — April 1998 Editor: Steve Skinner (coolnews@jila.colorado.edu)

TABLE OF CONTENTS

Stellar Abstracts

Hubble Space Telescope Imaging of the Mass-Losing Supergiant VY CMa

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The highly luminous M supergiant VY CMa is a massive star that appears to be in its final death throes, losing mass at high rate en route to exploding as a supernova. Subarcsecond resolution optical images of VY CMa, obtained with the Faint Object Camera (FOC) aboard the *Hubble Space Telescope*, vividly demonstrate that mass loss from VY CMa is highly anisotropic. In the FOC images the optical "star" VY CMa constitutes the bright, well resolved core of an elongated reflection nebula. The imaged nebula is ~ 3 arcsec (~ 4500 AU) in extent and is clumpy and highly asymmetric. The images indicate that the bright core, which lies near one edge of the nebula, is pure scattered starlight. We conclude that at optical wavelengths VY CMa is obscured from view along our line of sight by its own dusty envelope. The presence of the extended reflection nebula then suggests that this envelope is highly flattened and/or that the star is surrounded by a massive circumstellar disk. Such axisymmetric circumstellar density structure should have profound effects on post-red supergiant mass loss from VY CMa and, ultimately, on the shaping of the remnant of the supernova that will terminate its post-main sequence evolution.

Accepted by AJ (April 1998 issue)

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For preprints via ftp or WWW: file://space.mit.edu/pub/jhk/VYCMa (gzipped postscript; note, fig3.cps is a color ps file)

New Features in the EV Lacertae Flares Discovered By Fast High Precision UBVRI Photometry

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A flare's fine structure lies often below the detection limit for photometry data. UBVRI high-speed observations combined with synchronous monitoring at two telescopes situated far from each other allowed us to detect new small-amplitude features in the flare activity of EV Lacertae. Digital filtering of the light curves with a Gaussian window was used. We found that some flare events are composed of a flare and an intensity drop having a crater-shaped structure centered at the flare peak. Fading amplitudes extend from 0.1 to 0.01 mag.

Accepted by A&A

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Coordinated Observations of the Red Dwarf Flare Star EV Lac in 1994 and 1995

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Results of photometrical, spectral and radio astronomical studies of the flaring star EV Lac obtained in cooperative observations in 1994 and 1995 are given. The quantitative analysis of radiation of two powerful flares by colour–colour diagrams has confirmed the previous conclusion on essential heterogeneities of matter radiating in optical flares. Simultaneous observations of the star in $UBVRI$, K and H bands have not found out any correlation between optical flares and brightness variations in IR. A differential spottedness of light and dark semispheres of EV Lac is estimated using observations in separate seasons and a total stellar spottedness is determined within the framework of the zonal spottedness model. Spectra of quiet and active states of the star in the blue–green region in 1994 and in the red region in 1995 are described: characteristics of quiet chromosphere in lines H_α , H_β and H_γ , widening of these lines during flares, strengthening of lines of neutral and ionized helium, appearance of emissions of metals are presented. The monitoring of EV Lac in the decametric wavelength range with the UTR–2 led to registration of 18 radio bursts; one of them satisfies the majority of criteria of signals of non–terrestrial origin and coincides in time with an optical flare.

Submitted to Astron. Astrophys. Trans.

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Photospheric and Chromospheric Activity in the Late-Type Giant Component of the Evolved Binary System HD 185510

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UBV photometry and moderate resolution Hα spectrophotometry of the evolved binary system HD 185510 (sdB + K0 III), performed at Catania Astrophysical Observatory, are presented and discussed. The spectrophotometric data were collected in 1991, 1993, and 1994, while the photometric light curves were obtained in 1993, 1994 and 1995.

From the B and V photometry we determine a new photometric rotational period of $26^{d}.23$, confirming the asynchronous rotation of the cool giant component. The spectroscopic data confirm the $v \sin i$ value of 15 km s^{-1} measured by Fekel et al. (1993) and clearly reveal a filled-in Hα line with appreciable variations. The excess emission of the line, observed at any orbital phase, is found to be anticorrelated with the V light curve and is primarily ascribed to the chromospheric activity on the cool star.

The primary total eclipse is clearly visible in the U band, but undetectable in the V band. From the U observations we determined a total duration of the primary eclipse (from 1^{st} to 4^{th} contact) of $1^{d}.3883$, with the ingress lasting only 27 minutes. This new accurate monitoring and timing of the eclipse allowed us to improve the system solution which leads to $R_C = 8.8\ R_\odot$, $T_C = 4800$ K, $R_H = 0.11\ R_\odot$, $T_H = 30\,000$ K for the cool and hot stars respectively.

The evolution of HD185510B is discussed also in relation to the evolutionary status of HD 185510A and the synchronization time scale. HD 185510B is probably a sdB near the zero age extended horizontal branch, resulting from an enhanced mass loss in late case B or case A mass exchange with a possible common envelope phase. A small amount (15-20%) of mass loss from the system which can account for the strong IR excess is suggested.

Accepted by A&A

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For preprints via anonymous ftp : sunct.ct.astro.it; pub/frasca; hd185510.ps

High-Resolution Spectroscopy of Some Very Active Southern Stars

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We have obtained high-resolution echelle spectra of 18 solar-type stars that an earlier survey showed to have very high levels of Ca II H and K emission. Most of these stars belong to close binary systems, but 5 remain as probable single stars or well-separated binaries that are younger than the Pleiades on the basis of their lithium abundances and Hα emission. Three of these probable single stars also lie more than 1 magnitude above the main sequence in a color-magnitude diagram, and appear to have ages of 10 to 15 Myr. Two of them, HD 202917 and HD 222259, also appear to have a kinematical association with the pre-main sequence multiple system HD 98800.

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For preprints via ftp or WWW: http://xxx.lanl.gov as preprint astro-ph/9803111

IR Spectra of Young Magellanic Cloud Clusters and Starburst Galaxies: Constraints on the Temperature of Red Supergiants and New Estimates of Metallicity in Young Stellar Populations

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Infrared spectra of young stellar clusters in the Magellanic Clouds are used to derive information on the red supergiants dominating their 1.6 μm emission, and to obtain a new and independent estimate of their metallicities.

The most striking result is that red supergiants with low metallicity appear to be much cooler than predicted by evolutionary models, and this most probably reflects uncertainties in the calibration of the mixing–length parameter in the outermost layers of the stellar envelopes. The metallicity [Fe/H] can be estimated from the $W_\lambda(1.62)$ index which is here calibrated using synthetic stellar spectra, and the new scale is also applied to eight starburst galaxies. The resulting values of [Fe/H] range between –1.3 for the SMC cluster NGC330 (in excellent agreement with previous estimates) to –0.2 for the LMC cluster NGC1994. Starburst galaxies have metallicities ranging between –1.0 (NGC6240) and –0.5 (NGC7552). The spectra are also used to estimate the Carbon depletion which in MC clusters is found compatible with a 'standard' value of [C/Fe]$\simeq$–0.3. Interestingly, our spectra show possible evidence of significant variations of Carbon depletion in some starburst galaxies. Finally, the Silicon relative abundance is estimated from the $W_\lambda(1.59)$

index. In MC clusters we find [Si/Fe]$\approx$+0.5, i.e. values similar to those of old clusters in our galaxy and compatible with primordial Si–enhancement by type II supernovae.

Accepted by A&A

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A New Pleiades Member at the Lithium Substellar Boundary

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We present the discovery of an object in the Pleiades open cluster, named Teide 2, with optical and infrared photometry which place it on the cluster sequence slightly below the expected substellar mass limit. We have obtained low- and high-resolution spectra that allow us to determine its spectral type (M6), radial velocity and rotational broadening; and to detect H_α in emission and Li I 670.8 nm in absorption. All the observed properties strongly support the membership of Teide 2 into the Pleiades. This object has an important role in defining the reappearance of lithium below the substellar limit in the Pleiades. The age of the Pleiades very low-mass members based on their luminosities and absence or presence of lithium is constrained to be in the range 100–120 Myr.

Accepted by ApJ Letters

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Long-term Monitoring of Active Stars. VIII. UBV(RI)$_c$ Photometry Collected in February 1992

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High-precision UBV(RI)$_c$ photometry of 31 active stars, collected at the European Southern Observatory over the 14-29 February 1992 interval, is presented. Significant evolution of the light curves, period variations and, in most cases, evidence for long-term variability of the global degree of spottedness are found. Some of the spectral classifications are discussed and the inferred photometric parallaxes are compared, whenever possible, with the values measured by the Hipparcos satellite.
The stars observed are: HD 16157 = CC Eri, HD 17084 = UX For, HD 26354 = AG Dor, HD 32918 = YY Men, 1E 0505.0-0527 = EZ Eri, HD 293857, HD 34802 = YZ Men, EXO 052707-3329.2 = UX Col, HD 36705 = AB Dor, EXO 053237-0510.1 = V1321 Ori, HD 39917 = SZ Pic, EXO 055609-3804.4 = TY Col, HD 61245 = V 344 Pup, HD 81410 = IL Hya, HD 82558 = LQ Hya, HD 86005 = LZ Vel, HD 89499, HD 98712 = SZ Crt, SAO 202618 = V858 Cen, HD 101309 = V 829 Cen, HD 102077 = V 838 Cen, HD 106225 = HU Vir, HD 116544 = IN Vir, HD 119285 = V 851 Cen, HD 127535 = V 841 Cen, HD 136905 = GX Lib, HD 139084 = V 343 Nor, SAO 121177, HD 154338 = V991 Sco, HD 155555 = V 824 Ara, HD 158394/5.
Flare events were detected for the stars HD 16157 = CC Eri, EXO 055609-3804.4 = TY Col and HD 119285 = V851 Cen. Optical variability was discovered for the Pop II binary HD 89499.

Accepted by A&AS

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The Rotational Velocity of Low-mass Stars in the Pleiades Cluster

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We present new $v \sin i$ measurements for 235 low-mass stars in the Pleiades. The differential rotational broadening

has been resolved for all the stars in our sample. These results, combined with previously published measurements, provide a complete and unbiased rotation data set for stars in the mass range from 0.6 to $1.2 M_\odot$. Applying a numerical inversion technique on the $v \sin i$ distributions, we derive the distributions of *equatorial* velocities for low-mass Pleiades members. We find that half of the Pleiades dwarfs with a mass between 0.6 to $1\,M_\odot$ have rotation rates lower than $10\,\mathrm{km\,s^{-1}}$.
Comparison of the rotational distributions of low-mass members between IC 2602/2391 ($\approx 35\,$Myr) and the Pleiades ($\approx 100\,$Myr) suggests that G dwarfs behave like solid-bodies and follow Skumanich's law during this time span. However, comparison between Pleiades and older clusters –M34 ($\approx 200\,$Myr) and Hyades ($\approx 600\,$Myr)– indicates that the braking of slow rotators on the early main sequence is weaker than predicted by an asymptotical Skumanich's law. This strongly supports the view that angular momentum tapped in the radiative core of slow rotators on the zero age main sequence (ZAMS) resurfaces into the convective envelope between Pleiades and Hyades age. For the G-dwarfs, we derive a characteristic coupling time scale between the core and the envelope of about 100–200 Myr, which accounts for the observed evolution of surface rotation from the ZAMS to the Hyades.
The relationship between rotation and coronal activity in the Pleiades is in agreement with previous observations in other clusters and field stars. We show that the Rossby diagram provides an excellent description of the X–ray activity for all stars in the mass domain studied. The Pleiades data for slow and moderate rotators fills the gap between the X-ray–rotation correlation found for slow rotators and the X-ray "saturation plateau" observed for young fast rotators. The transition between increasing X-ray flux with rotation and X-ray saturation is observed at $\log(P/\tau) = 0.8 \pm 0.1$. These results strengthen the hypothesis that the "saturation" of the angular momentum loss process depends on the stellar mass.

Accepted by A&A

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The Solar Neighbourhood HR Diagram as a Quantitative Test for Evolutionary Time Scales

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The HIPPARCOS parallaxes have provided us with a precise HR diagram (HRD) of the solar neighbourhood, complete within certain limits. The scope of this work is a study of the stellar population densities in characteristic regions of the HRD to test stellar evolutionary time scales.

We examine two HRDs ($\mathrm{M_v} \leq 4.0$), both based on the single-star entries of the HIPPARCOS catalogue. One is constrained by distance $d \leq 50$pc (1337 stars found) and the other by $d \leq 100$pc (8984 stars found but more scattered). The stellar distribution on the main sequence (MS) was used to find the best matching present day mass function (PDMF) for $1.15 < M_*/M_\odot < 10$ in synthetic HRDs. For $1.6 < M_*/M_\odot < 4$ we derive an initial mass function (IMF) of $\mathrm{d}N_{\mathrm{IMF}}/\mathrm{d}\log M_* \propto M_*^{-1.8}$.

We then compare 4 synthetic HRDs, each based on a grid of evolutionary tracks with a different description of extended mixing (or "overshooting"), to the HIPPARCOS HRDs. As a diagnostic tool, we take star counts from characteristic HRD regions: the Hertzsprung gap (HG), the lower giant branch (LGB), the K giant clump (KGC) and the "cool wind" region (CW). The HG region turns out to be very sensitive to overshooting on the MS for models with $\approx 1.6 M_\odot$. We find that those 2 grids, which include the same overshooting as derived from earlier empirical tests, but with an onset (either gradual or sudden) around $1.7 M_\odot$, reproduce all star counts best.

Finally, our computed HRD can quantify a giant mass distribution for any evolved stage. Potential applications include the evolution of late stellar activity, or an estimate of the stellar gas and dust injection rates for the chemical evolution of the Galaxy.

Accepted by A&A

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On the Problem of Very Energetic Flares in Binary Systems

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Observations of several RS CVn and other late-type binary systems have revealed the occurrence of extremely energetic flares ranging from 10^{34} up to 10^{38} ergs. The energy of these flares has commonly been explained by the presence of a filament that can, due to the binary nature of the system, store much more energy than a filament on a single star for the same surface field strength.

Here, we show that this explanation is based on an unphysical model and we briefly analyse different mechanisms that could in principle account for these flares. Following previous authors, we suggest that either the flares are scaled-up versions of solar type flares due to a larger amount of magnetic flux involved in the eruption, or they are resultant from the interaction between the magnetospheres of the two stars.

Accepted by A&A

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Solar Abstracts

The Lack of Beryllium Depletion in the Sun and Implications for Stellar Mixing

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The chemical composition of the Sun and meteorites is the benchmark to which the abundances of all other astronomical objects are compared. A long standing problem has been the depletion of the solar photospheric Li abundance by a factor of ≈ 140 compared to the meteoritic (initial) value. This depletion requires non-standard mixing processes that can transport material downward from the Sun's convective zone (CZ) to temperatures sufficient for Li destruction. The most discussed and promising mixing models are associated with the transport of angular momentum in stars, and the resulting slow mixing process produces a simultaneous depletion of Li and Be. The model predictions are consistent with previous measurements of the solar photospheric Be abundance, which find a factor of 2 depletion from the meteoritic value. Here we show that previous determinations of the solar Be are in error because they did not fully account for the continuous opacity in the ultraviolet where the Be II lines are found. We find that the Sun has not depleted any Be since its formation. Mixing in the solar photosphere has therefore been more superficial, consistent with current helioseismic data.

Accepted by Nature

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A Catalogue of Accurate Wavelengths in the Optical Spectrum of the Sun

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We present accurate measurements of the central wavelengths of 4947 atomic absorption lines in the solar optical spectrum. The wavelengths, precise to a level $\sim 50 - 150$ m s^{-1}, are given for both flux and disc-centre spectra, as measured in relatively recent FTS solar atlases. This catalogue modernizes existing sources based on photographic measurements and provides a benchmark to test and perform wavelength calibrations of astronomical spectra. It will also permit observers to improve the absolute wavelength calibration of solar optical spectra when lamps are not available at the telescope.

Accepted by A&AS

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Intermediate Drift Bursts and the Coronal Magnetic Field

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We have analyzed 12 decimetric continuum (type IV) events during solar flares showing intermediate drift (IMD) fine structures in the 1 - 3 GHz band. This is the first time IMD patterns have been reported above 1 GHz and that the full spectrum of both continuum and IMD bursts has been covered. The IMD pattern was usually shifted to higher frequency and tends to occur later than the continuum. Average drift rates of IMD bursts per event were found by cross-correlation yielding $\dot{\nu}/\nu$ = -0.167 to -0.046 s^{-1}. The average second derivative of individual IMD bursts expressed as $\ddot{\nu}\dot{\nu}^{-2}\nu$ is 0.42 to 4.19. Normalized by the mean frequency, these high-frequency IMD bursts are found to be identical in their characteristics with this type of bursts below 1 GHz. The derived burst parameters require an important change in one of the two existing theories.

Accepted by A&A

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Coronal Heating in Active Regions as a Function of Global Magnetic Variables

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A comparison of X-ray images of the Sun and full disk magnetograms shows a correlation between the locations of the brightest X-ray emission and the locations of bipolar magnetic active regions. This correspondence has led to the generally accepted idea that magnetic fields play an essential role in heating the solar corona.

To quantify the relationship between magnetic fields and coronal heating, the X-ray luminosity of many different active regions is compared with several global (integrated over entire active region) magnetic quantities. The X-ray measurements were made with the SXT Telescope on the Yohkoh spacecraft; magnetic measurements were made with the Haleakala Stokes Polarimeter at the University of Hawaii's Mees Solar Observatory.

The combined dataset consists of 333 vector magnetograms of active regions taken between 1991 and 1995; X-ray luminosities are derived from time averages of SFD images of the given active region taken within $\pm$ 4 hours of each magnetogram. Global magnetic quantities include the total unsigned magnetic flux $\Phi_{tot} \equiv \int dA\ |B_z|$, $B^2_{z,tot} \equiv \int dA\ B_z^2$, $J_{tot} \equiv \int dA\ |J_z|$, and $B^2_{\perp,tot} \equiv \int dA B^2_{\perp}$, where J_z is the vertical current density, and B_z and $B_{\perp}$ are the vertical and horizontal magnetic field amplitudes, respectively.

The X-ray luminosity L_x is highly correlated with all of the global magnetic variables, but is best correlated with the total unsigned magnetic flux Φ_{tot}. The correlation observed between L_x and the other global magnetic variables can be explained entirely by the observed relationship between those variables and Φ_{tot}. In particular, no evidence is found that coronal heating is affected by the current variable J_{tot} once the observed relationship between L_x and Φ_{tot} is accounted for. A fit between L_x and Φ_{tot} yields the relationship $L_x \simeq 1.2 \times 10^{26}$ erg s^{-1} $(\Phi_{tot}/10^{22}\ \mathrm{Mx})^{1.19}$.

The observed X-ray luminosities are compared with the behavior predicted by several different coronal heating theories. The Alfvén wave heating model predicts a best relationship between L_x and Φ_{tot}, similar to what is found, but the observed relationship implies a heating rate greater than the model can accomodate. The "Nanoflare Model" of Parker predicts a best relationship between L_x and $B^2_{z,tot}$ rather than Φ_{tot}, but the level of heating predicted by the model can still be compared to the observed data. The result is that the Nanoflare Model predicts 1.5 orders of magnitude more heating than is observed. The "Minimum Current Corona" model of Longcope predicts a qualitative variation of L_x with Φ_{tot} that agrees with what is observed, but the model makes no quantitative prediction that can be tested

with the data. A comparison between L_x and the magnetic energy E_{mag} in each active region leads to a characteristic time scale that is typically about one month, placing an important observational constraint on coronal heating models.

Comparing the behavior of solar active regions with nearby active stars suggests that the relationship observed between L_x and Φ_{tot} may be a fundamental one that applies over a much wider range of conditions than is seen on the Sun.

Submitted to ApJ

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For preprints via ftp or WWW: http://sprg.ssl.berkeley.edu/~fisher/flmp.ps.gz

Announcement

Proceedings of the Workshop "Cool Stars in Clusters and Associations: Magnetic Activity and Age Indicators"

The proceedings of the Workshop "Cool Stars in Clusters and Associations: Magnetic Activity and Age Indicators" held in Palermo 20-23 May 1997 are available on the WWW at the URL http://www.astropa.unipa.it/Workshop97/proceed.html The proceedings of the Workshop will be published by the Memorie della Societa' Astronomica Italiana.

All the papers are in postscript gzipped format.

Submitted by: Giusi Micela

Upcoming Meetings

* First Announcement *

Workshop on Science with a Small Space Telescope

29-30 June 1998

Theoretical Astrophysics Center

Aarhus University, Denmark

The OFR (Danish Space Research Advisory Board) is funding a study into a microsatellite mission called MONS (Measuring Oscillations in Nearby Stars). The MONS payload would consist of a 30-cm telescope equipped with a CCD camera, launched in a geostationary transfer orbit. It would perform two-colour photometry on highly defocussed stellar images. The primary scientific aim is to measure oscillations in about 25 nearby solar-like stars by monitoring the brightness and colour fluctuations in each star for about one month. Other science applications include measuring the power spectrum of granulation, measuring rotation periods and the direct detection of extra-solar planets via their change in apparent brightness as a function of orbital phase. The aim of this workshop is to discuss the science, including target selection and any implications for the spacecraft design.

We welcome talks and posters on relevant subjects. Posters can also be sent by those unable to attend in person. There will be a published Proceedings.

Scientific Organising Committee:
Tim Bedding (Sydney Univ.), Joergen Christensen-Dalsgaard (TAC & Aarhus Univ.), Thomas Dall (Aarhus Univ.), Soeren Frandsen (Aarhus Univ.), Hans Kjeldsen (TAC; Chair)

Deadline for abstracts: 1 June 1998
Deadline for registration: 15 June 1998

MONS Web site: http://bigcat.obs.aau.dk/~hans/mons/

Registration form (please send to hans@obs.aau.dk)

(*Editor's Note:* Uncomment the lines below in the newsletter Latex file for the registration form.

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Abstract Guidelines

Abstracts for *COOLNEWS* are solicited for papers that have been recently accepted by or submitted to refereed journals, and for recent Ph.D. theses. Abstracts for conference proceedings articles are not posted in *COOLNEWS*. The subject matter should pertain directly to cool stars (spectral types F,G,K, 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

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