// COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 67 — August 2001 Editor: Steve Skinner (coolnews@jila.colorado.edu)

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Late-type Stars Members of Young Stellar Kinematic Groups – I. Single stars

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This is the first paper of a series aimed at studying the properties of late-type stars members of young stellar kinematic groups. We concentrate our study on classical young moving groups as: Local Association (Pleiades moving group, 20 - 150 Myr), IC 2391 supercluster (35 Myr), Ursa Major group (Sirius supercluster, 300 Myr), and Hyades supercluster (600 Myr); as well as on recently identified groups as: Castor moving group (200 Myr). In this paper we have compiled a preliminary list of single late-type stars possible members of some of these young stellar kinematic groups. Stars have been selected from previously established members of stellar kinematic groups based on photometric and kinematic properties as well as from candidates based on other criteria as their level of chromospheric activity, rotation rate, lithium abundance. Precise measurements of proper motions and parallaxes taken from Hipparcos Catalogue, as well as from Tycho-2 Catalogue, and published radial velocity measurements are used to calculate the Galactic space motions (U, V, W) and to apply the Eggen's kinematic criteria in order to determine the membership of the selected stars to the different groups. Additional criteria using age-dating methods for late-type stars will be applied in forthcoming papers of this series. A further study of the list of stars compiled here could lead to a better understanding of the chromospheric activity and their age evolution as well as of the star formation history in the solar neighbourhood. In addition, these stars are also potential search targets for direct imaging detection of sub-stellar companions

Accepted by MNRAS

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The Electron Pressure in the Outer Atmosphere of ϵ Eri (K2 V)

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Observations of ϵ Eri (K2 V) have been made with the Space Telescope Imaging Spectrograph on the Hubble Space Telescope. The spectra obtained show a number of emission lines which can be used to determine, or place limits on, the electron density and pressure. Values of the electron pressure are required in order to make quantitative models of the transition region and inner corona from absolute line fluxes, and to constrain semi-empirical models of the chromosphere. Using line flux ratios in Si III and O IV a mean electron pressure of $P_e = N_e T_e = 4.8 \times 10^{15}$ cm^{-3} K is derived. This value is compatible with lower and upper limits to P_e found from flux ratios in C III, O V and Fe XII. Some inconsistencies which may be due to small uncertainties in the atomic data used are discussed.

Accepted by MNRAS

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Modelling the H Lyman Lines in Evolved Late-Type Stars

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The importance of partial redistribution (PRD) in the modelling of the Lyman α and Lyman β emission lines of hydrogen in stellar atmospheres is examined using simple atmospheric models of a range of late-type stars. These models represent the sub-giant Procyon (F5 IV-V), and the two giants β Gem (K0 III) and α Tau (K5 III). These stars are selected to span a wide range of surface gravities: $1.25 < \log g < 4.00$. The calculations are performed using the computer code MULTI with the modifications made by Hubeny & Lites. It is found that PRD effects are highly significant, both in the direct prediction of the Lyman line profiles and in the application of hydrostatic equilibrium to calculate the atmospheric electron density in static atmospheric models.

Accepted by MNRAS

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The Residual Orbital Eccentricity in Close Binaries. An Application to Millisecond Binary Pulsars

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Density fluctuations in convective stars produce small variations of their outer gravitational field that give rise to a very small, though finite, orbital eccentricity in close binaries with convective components. We revisit the theory for such an effect, originally presented by Phinney (1992), and propose a new approach to compute the fluctuations of the outer gravitational field based on Chandrasekhar's virial theorem. It is applied to compute the eccentricities of binaries with a millisecond pulsar component in the framework of a simplified model of their evolution. The comparison with the observations allows us to test the models proposed for the formation of such systems, giving support to the evolutionary scenarios that connect them with low-mass X-ray binaries, and to provide a new test for turbulent convection models of giant stars.

Accepted by A&A

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Long-term Starspot Evolution, Activity Cycle and Orbital Period Variation of SZ Piscium

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A sequence of V-band light curves of the active close binary SZ Piscium (F8 V-IV+ K1 IV), extending from 1957 to 1998, is presented and analysed to derive the spot distribution and evolution on the component stars. In our modelling approach the Roche geometry and Kurucz's atmospheric models were adopted. The resulting maps of the spot surface distribution were regularized by means of the Maximum Entropy and Tikhonov criteria to take full advantage of the increased geometrical resolution during eclipses. By comparing the maps obtained with these two criteria, it was possible to discriminate between surface features actually required by the data and artifacts introduced by the regularization process. Satisfactory fits were obtained assuming spots on both components and the unspotted V-band luminosity ratio: $L_1/L_2 = 0.35 \pm 0.035$. The derived yearly spot distributions indicate that the spot patterns consist of two components, one uniformly and the other non-uniformly distributed in longitude, the latter suggesting the presence of preferential longitudes. Starspots at latitudes higher than $\sim 75°$ were not required to reproduce the photometric modulation. For the spot pattern on the less luminous F8 V primary component there are only some hints on the possible presence of spots around the substellar point facing the K1 IV secondary component. On the more luminous and larger secondary component there is clear evidence for the presence of three active longitudes. A stable active longitude around the substellar point facing the primary star appears to be quite compact with an extension of $\sim 40°$ on several maps. The other two active longitudes display irregular changes of the spot area and location. The variation of the total spotted area on the secondary component shows sizeable fluctuations and a possible short-term cycle of about 13 yr, which is more clearly apparent in the variation of the spotted area unevenly distributed in longitude. A longer-term cycle of about 30 yr with a markedly non-sinusoidal variation might also be present. The spatial association between photospheric spots and chromospheric plages (as detected in the UV lines) appears significant for the active region around the substellar point in the K1 IV component. A possible connection between magnetic activity and orbital period variation is suggested by comparing the variation of the total spotted area with the $O - C$ diagram of the primary eclipse times. The time span covered by the available data is, however, not long enough for us to draw any definite conclusions.

Accepted by A&A

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Three-Dimensional Spectral Classification of Low-Metallicity Stars Using Artificial Neural Networks

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We explore the application of artificial neural networks (ANNs) for the estimation of atmospheric parameters ($T_{\rm eff}$, $\log g$, and [Fe/H]) for Galactic F- and G-type stars. The ANNs are fed with medium-resolution ($\Delta\lambda \sim 1 - 2$ Å) non flux-calibrated spectroscopic observations. From a sample of 279 stars with previous high-resolution determinations of metallicity, and a set of (external) estimates of temperature and surface gravity, our ANNs are able to predict $T_{\rm eff}$ with an accuracy of $\sigma(T_{\rm eff}) = 135 - 150$ K over the range $4250 \leq T_{\rm eff} \leq 6500$ K, $\log g$ with an accuracy of $\sigma(\log g) = 0.25 - 0.30$ dex over the range $1.0 \leq \log g \leq 5.0$ dex, and [Fe/H] with an accuracy $\sigma([\rm Fe/H]) = 0.15 - 0.20$ dex over the range $-4.0 \leq [\rm Fe/H] \leq +0.3$. Such accuracies are competitive with the results obtained by fine analysis of high-resolution spectra. It is noteworthy that the ANNs are able to obtain these results *without* consideration of photometric information for these stars. We have also explored the impact of the signal-to-noise ratio (S/N) on the behavior of ANNs, and conclude that, when analyzed with ANNs trained on spectra of commensurate S/N, it

is possible to extract physical parameter estimates of similar accuracy with stellar spectra having S/N as low as 13. Taken together, these results indicate that the ANN approach should be of primary importance for use in present and future large-scale spectroscopic surveys.

Accepted by ApJ

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Solar Abstracts

On the Nature of the Transition Region from the Chromosphere to the Corona of the Sun

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One of the keys to understand coronal heating is to understand the (magnetic) structure of the atmosphere below the respective coronal features. The EUV emission lines formed in the thin transition region from the chromosphere to the corona present a sensitive tool to study the structure and dynamics of the lowermost corona and its connection to the chromosphere. Data from the SUMER spectrograph on SOHO show for the first time that broad components are a common feature of emission line profiles formed from some 40 000 K to 10^6 K. The contribution of that tail component to the total intensity of the line exhibits a trend with line formation temperature that peaks in the middle transition region with smaller contribution at high and low temperatures. The line width of the tail component shows a monotonic increase with temperature that is consistent with a passing Alfvén wave, which is in contrast to the trend in width of the line core. Together with previous observations this presents evidence that the line core and the tail component are formed in radically different physically regimes. It is proposed that these are small closed loops and coronal funnels, respectively, with the latter being the footpoints of large coronal loops. The new results on the structuring of the transition region will improve understanding on heating the corona and accelerating the solar wind.

Accepted by A&A

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The Case Against Cold, Dark Chromospheres

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Is the solar chromosphere always hot, with relatively small temperature variations ($\delta T/T \sim 0.1$); or is it cold most of the time, with temperature fluctuations that reach $\delta T/T \sim 10$ at the top of the chromosphere? Or, equivalently: Is the chromosphere heated continually, or only for a few seconds once every three minutes? Two types of empirical model, one essentially time independent and always hot, the other highly time dependent and mostly cold, come to fundamentally different conclusions. This paper analyzes the time-dependent model of the quiet, nonmagnetic chromosphere by Carlsson & Stein and shows that it predicts deep absorption lines, none of which is observed; intensity fluctuations in the Lyman continuum that are much larger than observed; and time-averaged emission that falls far short of the observed emission. The paper concludes that the solar chromosphere, while time dependent, is never cold and dark. The same conclusion applies for stellar chromospheres.

A complete, time-dependent model of the nonmagnetic chromosphere must describe two phenomena: (1) dynamics, like that modeled by Carlsson & Stein for chromospheric bright points but corrected for the geometrical properties of shocks propagating in an upward-expanding channel; and (2) the energetically more important general, sustained heating of the chromosphere, as described by current time-independent empirical models, but modified in the upper photosphere for the formation of molecular absorption lines of CO in a dynamical medium. This model is always hot and, except for absorption features caused by departures from local thermodynamic equilibrium, shows chromospheric lines only in emission.

Accepted by ApJ, to appear in v. 557, 10 August 2001
For preprints via WWW: http://arXiv.org/abs/astro-ph/0106072

Steady Part of Rotation and Toroidal Component of Magnetic Field in the Solar Convective Envelope

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With reasonable assumptions and approximations, we solve analytically the full set of Chandrasekhar's (1956) MHD equations in the convective envelope, for steady part of rotation and toroidal component of the magnetic field which may vary on diffusion time scales. Depending upon the two assumptions made about the boundary condition at the lower boundary, *viz.,* base of the convection zone, we have the following two solutions. In the first solution, we assumed that the Sun may be rotating uniformly at base of the convection zone. Except in the magnitudes of rotational velocities near the polar regions, the first solution yields similar rotational isocontours as that of helioseismology. Near the poles, the resulting solution yields faster rotation rates compared with that of the rotation rates inferred by helioseismology. Moreover, the chi-square fit of the resulting rotational results with the helioseismologically inferred rotational results is also not so good. These results lead to the second solution in which we made the assumption that the Sun may be rotating differentially at base of the convection zone. Compared with the helioseismic inferred results, the second solution yields almost similar rotational isocontours everywhere in the convective envelope. The chi-square fit improved significantly in this solution. This result suggests that, at base of the convection zone, *differential rotation is more likely* than uniform rotation. Correspondingly, it was necessary to solve the toroidal component of the magnetic field. Except near base of the convection zone, both the solutions yield similar field structure for the steady component of the toroidal magnetic field. This consists of a two-zone like field structure of intensity $\sim 1\,G$ near the surface and a four-zone like field structure of intensity $\sim 10^4\,G$ near base of the convection zone. However, near base of the convective envelope, compared to the field structure obtained from the first solution, the resulting field structure from the second solution is closer to the sites of sunspot formations. Implications of these results in the context of lithium depletion and solar activity phenomena are briefly discussed.

Accepted by Bull. Astron. Soc. India
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Brown Dwarf & Extrasolar Planet Abstracts

HD 80606 b, a Planet on an Extremely Elongated Orbit

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We report the detection of a planetary companion orbiting the solar-type star HD 80606, the brighter component of a wide binary with a projected separation of about 2000 AU. Using high-signal spectroscopic observations of the two components of the visual binary, we show that they are nearly identical. The planet has an orbital period of 111.8 days and a minimum mass of $3.9\,\mathrm{M_{Jup}}$. With $e = 0.927$, this planet has the highest orbital eccentricity among the extrasolar planets detected so far. We finally list several processes this extreme eccentricity could result from.

The planet was detected using radial-velocity measurements. The variable velocity of HD 80606 was first noticed by the *G–Dwarf Planet Search* (Latham 2000), a reconnaissance of nearly 1000 nearby G dwarfs that uses the HIRES high-resolution spectrograph mounted on the 10-m Keck 1 telescope at the W.M. Keck Observatory (Hawaii, USA) to identify extrasolar planet candidates. The star was then followed up by the ELODIE *Planet Search Survey* team (Mayor & Queloz 1996; Udry et al. 2000) using the ELODIE fiber-fed echelle spectrograph mounted on the Cassegrain focus of the 1.93–m telescope at the Observatoire de Haute-Provence (CNRS, France).

Accepted by A&A (Letters)

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The CORALIE Survey for Southern Extrasolar Planets V. 3 New Extrasolar Planets

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We report the detection of three new planetary companions orbiting the solar-type stars GJ 3021 (HD 1237), HD 52265 and HD 169830 using radial-velocity measurements taken with the CORALIE echelle spectrograph mounted on the 1.2-m "Leonard Euler" Swiss telescope at ESO–La Silla Observatory (Chile). All these planetary companions have longer orbital periods than the 51 Peg-like objects. The orbits are fairly eccentric. The minimum masses of these planets range from 1 to 3.3 M_{Jup}. The stars have spectral types from F8V to G6V. They are metal-rich.

We also present our radial-velocity measurements for three solar-type stars known to host planetary companions ι Hor (HD 17051), HD 210277 and HD 217107.

Accepted by A&A

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An Assessment of the Rotation Rates of the Host Stars of Extrasolar Planets

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The rotation periods of the host stars of extrasolar planets have been assessed against those of the Mt. Wilson stars, open cluster stars, and evolutionary stellar models that include rotation. They appear to be normal, modulo certain inconsistencies in various necessary inputs. Selection of candidate planet hosts for radial velocity surveys by low rotation or activity has resulted in a planet host sample skewed towards older stars. Thus, cross-comparisons must be age dependent. However, self-consistent ages are difficult to obtain, and activity ages show signs of systematic errors. There are indications that activity ages ought to be increased for lower-than-solar-mass stars and decreased for higher-than-solar-mass stars. Age uncertainties and a scarcity of measured rotation periods for planet host stars inflate the dispersion in older stars relative to those in open clusters. The presently available rotational models display inadequacies, most notably in producing fast-enough early-type stars. The fact that only one planet host star, τBoo, strongly suggests tidal spin-up, while of order ten systems suggest orbital circularization is explicable in terms of the differing timescales for these two phenomena. The rotational normalcy of the planet host stars and other considerations suggest that they are not especially different from other main sequence stars and that circumstellar matter and/or planets are probably ubiquitous, at least among sufficiently metal-rich solar-type stars.

Accepted by ApJ, to appear in v. 561, November 10, 2001

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For preprints via ftp or WWW: http://xxx.lanl.gov/abs/astro-ph/0107350

Atomic Data Abstracts

Line Ratios for Helium-like ions: Applications to Collision-dominated Plasmas

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The line ratios R and G of the three main lines of He-like ions (triplet: *resonance*, *intercombination*, *forbidden* lines) are calculated for C V, N VI, O VII, Ne IX, Mg XI, and Si XIII. These ratios can be used to derive electron density n_e and temperature T_e of hot late-type stellar coronae and O, B stars from high-resolution spectra obtained with *Chandra (LETGS, HETGS)* and *XMM-Newton (RGS)*. All excitation and radiative processes between the levels and the effect of upper-level cascades from collisional electronic excitation and from dielectronic and radiative recombination have been considered. When possible the best experimental values for radiative transition probabilities are used. For the higher-Z ions (i.e. Ne IX, Mg XI, Si XIII) possible contributions from blended dielectronic satellite lines to each line of the triplets were included in the calculations of the line ratios R and G for four specific spectral resolutions: *RGS*, *LETGS*, *HETGS-MEG*, *HETGS-HEG*. The influence of an external stellar radiation field on the coupling of the 2^3S (upper level of the *forbidden* line) and 2^3P levels (upper levels of the *intercombination* lines) is taken into account. This process is mainly important for the lower-Z ions (i.e. C V, N VI, O VII) at moderate radiation temperature (T_{rad}). These improved calculations were done for plasmas in collisional ionization equilibrium, but will be later extended to photo-ionized plasmas and to transient ionization plasmas. The values for R and G are given in extensive tables, for a large range of parameters, which could be used directly to compare to the observations.

Accepted by A&A

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For preprints via WWW: http://arXiv.org/abs/astro-ph/0107329

Circumstellar Environments and Activity in Young and Evolved Stars

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Ph.D dissertation directed by: B.H. Foing and M.T.V.T. Lago

Ph.D degree awarded: June 2001

The main goal behind my thesis research is to investigate activity and variability in two very distinct types of stars and circumstellar environments: the giant ultra-fast rotator FK Comae and the T Tauri star SU Aurigae.

One of the most useful tools in activity and variability studies is the analysis of spectroscopic time series. Not only a well-sampled continuous time series is required, also a large wavelength range is essential in order to describe the different physical conditions throughout the atmosphere. In this context the multi-site MUSICOS campaigns and the MUSICOS echelle spectrographs were decisive in gathering the data sets analysed here. Specific echelle data reduction techniques were applied to the MUSICOS data. The FK Comae data sets were mostly obtained with the MUSICOS spectrographs, during the commissioning of the ESA-MUSICOS instrument at the Isaac Newton Telescope in La Palma, and at the Télescope Bernard Lyot in France. The data set on SU Aurigae was obtained at five telescopes during the MUSICOS 1996 campaign; this data set is unique both in terms of time sampling and phase coverage. I applied specific analysis techniques (e.g. profile decomposition and cross-correlation analysis) to quantify the observed multi-line variability. As one of the organisers, I describe the goals, preparation and execution of the successful MUSICOS 1998 campaign. For both FK Comae and SU Aurigae, I also analyse polarimetric observations aimed at detecting magnetic fields in these stars.

FK Comae is an evolved giant star, with high rotation rate and extreme activity. The Balmer excess emission and the He I D3 profiles are analysed. I used a multi-component technique to identify several velocity components in Hα and Hβ which were traced in phase. From the Hα time series, I constructed a two dimensional emission map using a back-projection technique. The results of the present analysis indicate that the excess emission arises from the near-circumstellar environment, probably from prominence-like structures locked in co-rotation with the stellar surface by magnetic fields. These structures have strong intrinsic variability, but they seem to be stable for at least a few rotation periods.

The study of the disk-star interaction in T Tauri stars is essential to understand their activity and circumstellar environment. Both accretion and outflows play a role in the formation of emission lines. I analysed some SU Aurigae line profiles (Hα, Hβ, Na I D and He I D3) in order to constrain the geometry and dynamics of its magnetosphere. Different time lags were found between the accretion signatures, and I suggest that this time-lagged behaviour can occur if the magnetic field lines in the oblique magnetosphere are azimuthally distorted. Plasma outflows, powered by the disruption of the magnetic field lines, might be the cause of the transient absorption features also present in the data set.

In order to probe the outer circumstellar environment of SU Aurigae, its spectral energy distribution is modelled, from ultra-violet to radio wavelengths. I used two distinct approaches to model the circumstellar excess emission: a disk in hydrostatic and radiative equilibrium, and a spherically symmetric dust envelope with a cavity where resides a flat blackbody disk. Both the shell and disk dimensions clearly indicate a very extended circumstellar matter distribution. Both models provide good agreement to the spectral energy distribution and cannot be distinguished with the limited observational data available.

(*continued* →)

The unique and new data sets presented here allowed to address problems and constrain models of chromospheric (magnetic) activity and of magnetospheric coupling with circumstellar environments of two classes of stars. I discuss the perspectives for follow up on this research, with the next generation of telescopes and instruments, on the ground and in space.

Thesis-related Publications: A&A, 362, 615; A&A, 343, 213

JOB OPENING

Marie Curie Fellowships
Osservatorio Astronomico di Palermo Giuseppe S. Vaiana
Palermo, Italy

Closing date: 1 October 2001

Osservatorio Astronomico di Palermo Giuseppe S. Vaiana expects to appoint one fellow in the area of **stellar high resolution optical spectroscopy** under the European Commission's Marie Curie Development Host Fellowship Scheme.

The successful candidate is expected to actively participate in the analysis of stellar high resolution optical spectra of late type stars with the aim to determine the photospheric parameters with emphasis on elemental abundances. He/she is expected to also participate in development and extension of our research program on the relationships between stellar activity and stellar populations..

Skills in spectral analysis, modeling, spectral synthesis and multi fiber spectroscopy will be an advantage.

Candidates should have a PhD in a relevant field or at least four years of full-time research experience at postgraduate level other than doctoral studies. The ability to work in team and possibly a strong and competitive research program are important skills.

The applicant must be a national of a Member State of the European Community (other than Italy) or an Associated State, or otherwise residing in the Community for at least the last five years. The fellow must be of age 35 years or less (allowance is made for time actually served in compulsory military or civil service and for childcare with a maximum of 2 years per child). In addition candidates should not have been resident in Italy for more than 12 months in the two years prior to selection. Gross salary, including all compulsory deductions under italian legislation, is fixed at 3813 Euro per month plus a mobility allowance for the duration of the contract, which is expected to last for 24 months. Female candidates are explicitly encouraged to apply.

Applications (specifying the Id. Number 2), including CV, publication list, description of applicant's research interests/program (all documents above should be signed by the candidate), documents certifying the doctoral degree or four years of full time research experience and two letters of recommendation should arrive by 1st October 2001 at:

Osservatorio Astronomico di Palermo
Marie Curie Fellowship Selection - Id. 2
Piazza del Parlamento 1
I-90134 Palermo, Italy

For further information contact:
Giusi Micela - giusi@oapa.astropa.unipa.it or http://www.astropa.unipa.it

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` .