COOLNEWS

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We report the analysis of the high-resolution soft X-ray spectrum of the nearby F-type star Procyon in the wavelength range from 5 to 175 Å obtained with the Low Energy Transmission Grating Spectrometer (LETGS) on board Chandra and with the Reflection Grating Spectrometers (RGS) and the EPIC-MOS CCD spectrometers on board XMM-Newton. Line fluxes have been measured separately for the RGS and LETGS. Spectra have been fitted globally to obtain self-consistent temperatures, emission measures, and abundances. The total volume emission measure is $\sim 4.1 \times 10^{50}$ cm^{-3} with a peak between 1 and 3 MK. No indications for a dominant hot component ($T \gtrsim 4$ MK) were found. We present additional evidence for the lack of a solar-type FIP-effect, confirming earlier EUVE results.

Accepted by A&A

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Carbon and Nitrogen Abundances in the Coronae of Algol B and Other Evolved stars: Evidence for CNO-cycle Processed Material

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Using the Ly$_\alpha$-lines of carbon and nitrogen measured in *Chandra* Low Energy Transmission Grating Spectrometer (LETGS) spectra we study the coronal abundances of these elements in a sample of late-type stars including dwarf stars, the prototypical eclipsing binary Algol, the single giant β Cet, and three RS CVn binaries. In the main sequence stars of our sample the flux ratio R_{NC} between the Ly_α-lines of nitrogen and carbon is below unity, while R_{NC} is found to be ≈ 8.5 for β Cet and > 23.3 for Algol. These values are more than an order of magnitude larger than expected from a solar abundance plasma in collisional equilibrium regardless of the chosen temperature structure. We therefore interpret the anomalously large R_{NC}-ratios as being due to the exposure of CNO-cycle processed material at the surfaces and in the coronae of Algol and β Cet.

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For preprints via ftp or WWW: http://www.hs.uni-hamburg.de/~st9h306/cno.ps.gz

Doppler Imaging of Stellar Surface Structure XVIII. The Very Active RS CVn Binary UZ Librae Revisited

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We present eight Doppler images of UZ Librae from the years 1994, 1996, 1997, 1998 and 2000. These maps indicate a preferred temperature distribution from one year to the other and suggest preferred spot locations for at least the seven years of our observations. Two equatorial active regions appear facing towards and opposite the (unseen) companion star. A large and cool polar spot, with two or maybe three appendages extending down to a latitude of 40 deg −50 deg, is present and causes the long-term light variability of UZ Lib. The appendages appear at longitudes very similar to the two equatorial active regions and sometimes are possibly even attached to them. No coherent sign of differential rotation is found for the equatorial regions up to a latitude of approximately +50 deg, but the polar appendages may indicate a general acceleration of the polar regions. If interpreted as being due to differential rotation, if real at all, then UZ Lib clearly exhibits a non-solar flow pattern.

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Simultaneous Optical and X-ray Observations of Flares and Rotational Modulation on the RS CVn Binary HR 1099 (V711 Tau) from the MUSICOS 1998 Campaign

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We present simultaneous and continuous observations of the Hα, Hβ, He I D_3, Na I D_1,D_2 doublet and the Ca II H & K lines for the RS CVn system HR 1099. The spectroscopic observations were obtained during the MUSICOS 1998 campaign involving several observatories and instruments, both echelle and long-slit spectrographs. During this campaign, HR 1099 was observed almost continuously for more than 8 orbits of 2.8 days. Two large optical flares were observed, both showing an increase in the emission of Hα, Ca II H & K, Hβ and He I D_3 and a strong filling-in of the Na I D_1,D_2 doublet. Contemporary photometric observations were carried out with the robotic telescopes APT-80 of Catania and Phoenix-25 of Fairborn Observatories. Maps of the distribution of the spotted regions on the photosphere of the binary components were derived using the Maximum Entropy and Tikhonov photometric regularization criteria. Rotational modulation was observed in Hα and He I D_3 in anti-correlation with the photometric light curves. Both flares occurred at the same binary phase (0.85), suggesting that these events took place in the same active region. Simultaneous X-ray observations, performed by ASM on board RXTE, show several flare-like events, some of which correlate well with the observed optical flares. Rotational modulation in the X-ray light curve has been detected with minimum flux when the less active G5V star was in front. A periodicity in the X-ray flare-like events was also found.

Submitted to A&A

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The Coronal Topology of the Rapidly Rotating K0 Dwarf AB Doradus I. Using Surface Magnetic Field Maps to Model the Structure of the Stellar Corona

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We re-analyse spectropolarimetric data of AB Dor taken in 1996 December using a surface imaging code that can model the magnetic field of the star as a non-potential current-carrying magnetic field. We find that a non-potential field needs to be introduced in order to fit the dataset at this epoch. This non-potential component takes the form of a strong unidirectional azimuthal field of a similar strength to the radial field. This azimuthal field is concentrated around the boundary of the dark polar spot recovered at the surface of the star using Doppler imaging. As polarization signatures from the center of starspots are suppressed, it is unclear whether or not this non-potential component genuinely represents electric current at the unspotted surface or whether it results from the preferred detection of horizontal field in starspot penumbrae. This model contains 20% more energy than the corresponding potential field model at the surface. This amount of free energy drops to under 1% about $1\,R_*$ above the photosphere.

We use these surface maps to model the coronal structure of the star. The mixed radial polarities at the pole in the surface maps support closed coronal loops in the high latitude regions, indicating that a component of the X-ray emission may originate in this area. Assuming that the field remains closed out to $5\,R_*$ we find stable surfaces where prominences may form out to the observed distances using this coronal model.

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On the Feasibility of the Detection of Differential Rotation in Stellar Absorption Profiles

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Stellar differential rotation invokes subtle effects on line absorption profiles which can be best studied in the Fourier domain. Detailed calculations of the behavior of Fourier transformed profiles with respect to varying differential rotation, limb darkening and inclination angles are presented. The zero positions of the Fourier transform are found to be very good tracers of differential rotation. The ratio of the first two zero positions σ_2/σ_1 can be easily measured and is a reliable parameter to deduce the amount of differential rotation. It is shown that solar-like differential rotation (equatorial regions have larger angular velocity then polar regions) has an unambigious signature in the Fourier domain and that in certain cases it can easily be distinguished from limb darkening effects. A simple procedure is given allowing the determination of the amount of differential rotation by the knowledge of the first two zero positions of a line profile's Fourier transform alone (i.e., without the need for thorough atmospheric modelling) under the assumption of a linear limb darkening law with a limb darkening coefficient of $\epsilon = 0.6$.

A&A 384, 155

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Can Star Spots Mimic Differential Rotation?

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The search for stellar differential rotation in Fourier-transformed profiles utilizes subtle deviations from the standard rotation profile. We investigate the influence of stellar spots on the results obtained with the Fourier Transform Method. Different spot configurations, especially polar spots, are examined, and their influence on Fourier-transformed line profiles studied. We found that polar spots cannot mimic solar-like differential rotation and are thus not critical for the use of the Fourier Transform Method. Although not indicated by Doppler imaging, other configurations may occur on stellar surfaces and their influence on the analysis is discussed. A symmetric distribution of spots in an activity belt leads - in a small region of the parameter space - to line profiles that are very similar to the signatures produced by differential rotation.

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Hα Spectroscopy and BV Photometry of RT Lacertae

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Contemporaneous spectroscopic and photometric BV observations of the RS CVn type eclipsing binary RT Lacertae were performed in summer 2000. The photometric observations were obtained at the Ege University Observatory, while the spectroscopic ones were carried out at Catania Astrophysical Observatory in the spectral range 5860–6700 Å.
We obtained a high quality radial velocity curve of the system that allowed us to give more accurate values of the orbital parameters. A steady decrease of the barycentric velocity from 1920 to 2000 has been pointed out and has been discussed in the context of a third body hypothesis.
Through the subtraction of a "synthetic" spectrum, built up with spectra of inactive standard stars, we detected Hα excess emission which fills in the photospheric absorption profiles of both components.
With the exception of a few spectra, taken close to the eclipses, in which some extra absorption or a faint double-peaked broad emission appears, there is no further evidence of circumstellar matter in this system, as suggested in previous works. The hotter and more massive star appears also as the more active at a chromospheric level, since it has a Hα flux about ten times greater than the companion, on average.
Rotational modulation of the Hα emission has been detected in both stars. The hemisphere of the more massive star facing the observer at phase 0.75 appears brighter (in Hα) than that seen at phase 0.25, while for the less massive G9 IV star the maximum Hα emission is seen around phase $0.0 - 0.1$.

From the analysis of the contemporaneous light curve (Lanza et al. [?]), the more massive G5 IV star results to be more active than the companion at a photospheric level, in agreement with the chromospheric behaviour observed in Hα. In addition, the starspots of the G5 IV star are mainly located in the Hα brighter hemisphere, suggesting a close spatial association of spots and plages in this star. The G9 IV star displays instead the maximum Hα emission at the phase of maximum visibility of the smaller spotted area found from the light-curve analysis. The minimum Hα emission occurs when the more heavily spotted region is visible.

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Solar Abstracts

Small-scale Topology of Solar Atmospheric Dynamics V. Acoustic Events and Internetwork Grains

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We use high-quality observations from the Dunn Solar Telescope at NSO/Sacramento Peak to study spatio-temporal co-location of acoustic flux events in the photosphere and internetwork grains in the chromosphere. The events are diagnosed as sites with excess upward-propagating five-minute waves measured from Dopplergrams. The grains are repetitive bright internetwork features in simultaneous Ca II K_{2V} filtergrams. We find that the largest-flux sites in the granulation have appreciably larger than random probability to co-locate with exceptionally bright chromospheric internetwork grains, at an average delay of about two minutes which is likely to represent sound travel time to the chromosphere. This finding strengthens the case for acoustic grain excitation.

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Penumbral Structure and Kinematics from High-spatial-resolution Observations of Ca II K

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High-spatial-resolution spectra of the Ca II K line obtained with the Swedish Vacuum Solar Telescope (SVST) on La Palma are used to study the penumbra of a sunspot. The observed radiation temperatures in the Ca II K wing are used to derive the temperature stratification of fine-structure elements in the penumbra. It is found that in general, over the observed atmospheric depth range, penumbral structures keep their relative brightness identity with respect to their local surroundings, i.e., bright (dark) structures in the lower photosphere remain bright (dark) in the upper photosphere. Hot structures have a larger temperature difference between the bottom and the top of the photosphere than cool structures. Three semi-empirical atmosphere models, a cool, hot and mean model, are presented as being representative for the temperature stratification of penumbral fine structure. The mean temperature distribution of the centre-side penumbra is found to be up to 50 K hotter in the higher photosphere as compared to the limb-side penumbra. Hot structures being more numerous in the centre-side penumbra can account for this difference. These are primarily found near the outer penumbral boundary. It is suggested that the asymmetry can be explained by a differential line-of-sight effect that is caused by isotherms in bright structures having in the higher photosphere a tilt angle of approximately 7° with the horizontal, pointing downward towards the outer boundary. Line blends in the extended Ca II K wing are selected to study the Evershed effect and its height dependence. At a number of locations, the Evershed effect is found to be concentrated in channels which have a tendency to coincide with dark filaments. A weak correlation between brightness and velocity signal is found but also a number of bright structures with a significant Evershed signal. Simple numerical tests of flow channels in the penumbral atmosphere are performed to confront existing theoretical models with the observations. From these experiments it is found that the bulk of the flow must be concentrated in the lower atmospheric layers, i.e., below 200 km, and must have a velocity not higher than 6 km s^{-1}. A channel width of 200 km is found to give the best reproduction of the observed velocities, so that the flow is either concentrated in a single channel or in a bundle of narrower channels. No direct indication is found of the Evershed channels being elevated above the continuum, and it is estimated that the flow channels reach down to at least 50 km above the continuum.

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Low-Mass & Substellar Abstracts

Evidence for Cloud Disruption in the L/T Dwarf Transition

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Clouds of metal-bearing condensates play a critical role in shaping the emergent spectral energy distributions of the coolest classes of low-mass stars and brown dwarfs, L and T dwarfs. Because condensate clouds in planetary atmospheres show distinct horizontal structure, we have explored a model for partly cloudy atmospheres in brown dwarfs. Our model successfully reproduces the colors and magnitudes of both L and T dwarfs for the first time, including the unexpected brightning of the early- and mid-type T dwarfs at J-band, provided that clouds are rapidly removed from the photosphere at $T_{eff} \approx 1200$ K. The clearing of cloud layers also explains the surprising persistence and strengthening of gaseous FeH bands in early- and mid-type T dwarfs. The breakup of cloud layers is likely driven by convection in the troposphere, analogous to phenomena observed on Jupiter. Our results demonstrate that planetary-like atmospheric dynamics must be considered when examining the evolution of free-floating brown dwarfs.

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A Search for Variability in the Active T dwarf 2MASS 1237+6526

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We present spectroscopic and imaging observations of the active T dwarf 2MASS 1237+6526, intended to investigate the emission mechanism of this cool brown dwarf. The Hα emission line first detected in 1999 July appears to be persistent over 1.6 years, with no significant variation from $\log_{10}(L_{H\alpha}/L_{bol}) = -4.3$, ruling out flaring as a possible source. The relatively high level of emission in this object appears to be unique amongst observed late-L and T dwarfs. One of our spectra shows an apparent velocity shift in the Hα line, which could be indicative of an accretion hot spot in orbit around the brown dwarf; further confirmation of this shift is required. J-band monitoring observations fail to detect any significant variability (e.g., eclipsing events) at the ±0.025 mag level over periods of up to 2.5 hours,

and there appears to be no statistical evidence of variability for periods of up to 14 hours. These limits constrain the mass of a hypothetical interacting secondary to $M_2 \lesssim 20\ M_{Jup}$ for inclinations $i \gtrsim 60°$. While our observations do not explicitly rule out the binary hypothesis for this object, it does suggest that other mechanisms, such as youthful accretion, may be responsible.

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For preprints via ftp or WWW: http://arXiv.org/abs/astro-ph/0201382

Ph.D. Thesis Abstracts

Extreme Ultraviolet and X-Ray Studies of Flare Heating and Elemental Composition of Stellar Coronae

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Stellar coronae are the most numerous X-ray sources in our Galaxy. They i) display a rich spectrum of X-ray atomic lines from cosmic elements in collisional ionization equilibrium, ii) exhibit a wide range of temperatures ($\approx$ 1–100 MK) and densities (10^9–10^{12} cm^{-3}); and iii) coronal magnetic fields frequently interact through magnetohydrodynamic processes. Stellar coronae are therefore ideal astrophysical plasma laboratories. Their study also pertains to the origin of cosmic rays, to the impact of the young Sun on planetary atmospheres and life, and to fundamental plasma or atomic physical processes.

This doctoral thesis is aimed at studying physical processes taking place in stellar coronae. I give a short overview of the principal findings in the field of solar and stellar coronae that are relevant for the subsequent chapters in this thesis. Short technical overviews of the *Extreme Ultraviolet Explorer* and *XMM-Newton* satellites are given, since their data were of principal importance.

The remaining portion of the thesis is divided essentially into two parts. In the first part (*Flare Statistics in Active Stars*), the contribution of flares as a *statistical ensemble* to coronal heating in young active stars is investigated. In a pilot study with two young solar analogs, the flare occurrence rate distribution in energy is found to be a power law with an index $\alpha \approx 2.2 \pm 0.2$. For power-law indices $\alpha > 2$, flares with small energies contribute most to the total emitted flare energy; this ensemble of flares may suffice to explain all of the observed flaring and "quiescent" X-ray emissions. A considerable fraction, if not all, of the energy required to heat the coronae could thus be provided by flares. From a comprehensive study of the flare activity in main-sequence cool stars (spectral types F to M) with the *Extreme Ultraviolet Explorer*, power laws are found to describe approximately the flare occurrence rate distributions in energy. The power-law indices range $\alpha = 1.5 - 2.6$, with a suggested trend toward flatter distributions for later-type stars. Although detected flares contributed ≈ 10 % of the observed radiated power loss, a continuation of the power laws to minimum radiated energies of $E_{\min} \approx 10^{29} - 10^{31}$ ergs could be sufficient to balance all radiative losses. A clear correlation between the occurrence rate of flares with energies above a critical energy (10^{32} ergs) and the X-ray luminosity implies that energetic flares occur more often in X-ray bright stars than in X-ray faint stars. Saturation of the X-ray emission and of the occurrence rate of flares is however also observed. Taking advantage of a very long exposure on the flare star AD Leonis, its flare rate distribution in radiated energy has been investigated. The observed

light curve has been compared with light curves synthesized from model flares that are distributed in energy according to a power law with selectable index α. Acceptable solutions range $\alpha = 2.1 - 2.5$. The results again suggest that flares can play an important role and contribute a significant amount of energy to coronal heating in active stars.

In the second part of this thesis (*High-Resolution X-Ray Spectroscopy*), high-resolution X-ray spectra from the *XMM-Newton* satellite have been analyzed. A time-dependent analysis of a large flare in the RS CVn binary HR 1099 has been performed. The flare emission measure distribution shows two distinct components: a very hot plasma (up to 100 MK) that evolves rapidly, and a stable quiescent plasma. The abundances of low-First Ionization Potential (FIP) elements increase significantly during the flare, while the abundance of the high-FIP element Ne stays constant at the quiescent value. The high signal-to-noise ratio of the RGS X-ray spectrum of Capella shows bright emission lines from Fe L-shell lines. Its emission measure distribution displays a sharp peak around 7 MK. The best-fit model, however, does not reproduce numerous lines, owing to their absence in the current atomic databases. The spectral variability of the coronal plasma in a very active star, AB Doradus, has been studied. The high-resolution spectrum shows flux changes in lines of highly ionized Fe during the flares, and an increase of the continuum. Elemental abundances increase in the early flare phases by a factor of three, however an inverse FIP effect (high-FIP elements overabundant relative to low-FIP elements) is observed in the quiescent corona of AB Dor. The average density of the cool plasma is $\approx 3 \times 10^{10}$ cm^{-3}; this value does not change during the flares. For the first time, both Castor A and B of the multiple stellar system Castor AB and YY Geminorum have been spatially separated and identified as frequent flaring sources. The light curve of the eclipsing binary YY Gem show three deep eclipses. A 3-D inversion of the light curve shows that the coronae of both components are similarly active and relatively compact. In an investigation of the elemental abundances in stellar coronae that cover a wide range of activity, elements with a low First Ionization Potential are underabundant relative to high-FIP elements in the most active stars, signifying an inverse FIP effect, while less active stars show low-FIP abundance enhancements by factors of about $5 - 7$ (normal FIP effect). This suggests a transition from the inverse to the normal FIP effect as a consequence of decreasing coronal activity.

Finally, an outlook to future investigations of magnetically active stars is given.

Thesis-related Publications: ApJ, 513, L53; ApJ, 541, 396; A&A, 365, L318; A&A, 356, L329; A&A, 365, L336; A&A, 365, L344; one submitted publication; two publications in preparation

Postdoctoral Position(s)

Institute of Theoretical Astrophysics
University of Oslo (Norway)

One or more positions will be available during 2002 for the project "Solar and Heliospheric Plasmas". The goal of the project is to arrive at a coherent description of the physics of the outer solar atmosphere, heliosphere and their effects on the geosphere. This will be accomplished by combining the complimentary expertise of existing research groups in atmosphere and plasma modelling with expertise in large scale scientific visualization. Preference will be given to individuals having experience in numerical simulations involving hydrodynamical modeling, radiative transfer and/or parallel computing. Length of employment will be for two-three years. The salary is NOK 339,100 per year.

Applicants should send a curriculum vitae, bibliography, a one or two-page statement of research interests, and letters of recommendation from three referees to

Det matematisk-naturvitenskapelige fakultet
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More information can be obtained from:

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see also: http://www.astro.uio.no/~matsc/shp

JOB OPENING

Postdoctoral Position

Substellar Astrophysics
Institute for Astronomy, University of Hawaii

The Institute for Astronomy, University of Hawaii, invites applications for one NASA/STSCI/UH funded postdoctoral research fellowship. The position is available from 1st November 2002, or as soon as possible thereafter, to work primarily on the observation and interpretation of substellar-mass objects (brown dwarfs and extrasolar planets). Candidates should have, or be about to obtain, a relevant PhD. Familiarity with the field, and experience with optical and infrared photometry and spectroscopy, and numerical modelling techniques would be an advantage. Salary will be within the range $36,000 to 51,000$ per year (before taxes) depending on the qualifications and experience of the successful candidate. The appointment will be made initially for one year, and is renewable for up to five years based on performance and availability of funds. Relocation expenses up to $2000 are available. The research fellow will have access to all the telescopes installed in Mauna Kea and Haleakala observatories.

Further information can be obtained from

Dr. E. L. Martin
Institute for Astronomy, University of Hawaii
2680 Woodlawn Drive
Honolulu HI 96822 USA
email: ege@ifa.hawaii.edu

to whom applications (CV, statement of research interests, list of publications, and the names and contact details of three referees) should be sent by 2 July 2002. Email applications are preferred.

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` .