COOLNEWS

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Stellar Abstracts

The EUVE Point of View of AD Leo

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All the *Extreme Ultraviolet Explorer* (EUVE) observations of AD Leo, totalling 1.1 Ms of exposure time, have been employed to analyze the corona of this single M dwarf. The light curves show a well defined quiescent stage, and a distribution of amplitude of variability following a power law with a ~ -2.4 index. The flaring behavior exhibits much similarity with other M active stars like FK Aqr or YY Gem, and flares behave differently from late type active giants and subgiants. The Emission Measure Distribution (EMD) of the summed spectrum, as well as that of quiescent and flaring stages, were obtained using a line-based method. The average EMD is dominated by material at log T(K)$\sim$6.9, with a second peak around log T(K)$\sim$6.3, and a large increase in the amount of material with log T(K)$\gtrsim$7.1 during flares, material almost absent during quiescence. The results are interpreted as the combination of three families of loops with maximum temperatures at log T(K)$\sim$6.3, $\sim$6.9 and somewhere beyond log T(K)$\gtrsim$7.1. A value of the abundance of [Ne/Fe]=1.05$\pm$0.08 was measured at log T(K)$\sim$5.9. No significative increment of Neon abundance was detected between quiescence and flaring states.

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Magnetic Activity in the Young Solar Analog LQ Hya. I. Active Longitudes and Cycles

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We present the first evidence that a single active dwarf of solar type can show a long-lived, nonaxisymmetric spot distribution – active longitudes on opposite hemispheres, similar to evolved, rapidly rotating RS CVn-type binary stars. We analyse new as well as published photometric observations of the young active dwarf LQ Hya, spanning almost

20 years. We find that activity of the star has three activity cycles: a 5.2-yr "flip-flop" cycle, a 7.7-yr period in the amplitude modulation of the brightness and an approximately 15-yr period in variations of the mean brightness. The two shorter cycles are related to the alternating active longitudes and are similar to cycles observed in RS CVn-type stars. The 15-yr cycle reflects periodic changes of the mean spottedness of the star and resembles the solar 11-year cycle. The spot rotation period (about 1.6 days) changes during the 15-yr cycle, indicating the presence of small differential rotation. The lengths of the three cycles are related as 3:2:1, with the repetition of the spot configuration after 15 years. We discuss the possibility that the observed spot cycles represent two different magnetic dynamo modes operating in LQ Hya: an axisymmetric mode, as in the Sun, and a nonaxisymmetric higher order mode with two cycles in spot patterns. Our results suggest that young stars exhibit their cycles in spot distribution, as seen in LQ Hya. This is in contrast to the conclusion based on the analysis of Ca II H&K emission from plages. The results suggest also that the Vaughan-Preston gap represents a transition from a multiple-mode dynamo to a single-mode dynamo.

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Inferring X-ray Coronal Structures from Zeeman-Doppler Images

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We have modelled the X-ray emission from the young rapid rotator AB Doradus ($P_{rot} = 0.514$ days) using as a basis Zeeman-Doppler maps of the surface magnetic field. This allows us to reconcile the apparently conflicting observations of a high X-ray emission measure and coronal density with a low rotational modulation in X-rays. The technique is to extrapolate the coronal field from the surface maps by assuming the field to be potential. We then determine the coronal density for an isothermal corona by solving hydrostatic equilibrium along each field line and scaling the plasma pressure at the loop footpoints with the magnetic pressure. We set the density to zero along those field lines that are open and those where at any point along their length the plasma pressure exceeds the magnetic pressure. We then calculate the optically thin X-ray emission measure and rotational modulation for models with a range of coronal densities. Although the corona can be very extended, much of the emission comes from high-latitude regions close to the stellar surface. Since these are always in view as the star rotates, there is little rotational modulation. We find that emission measures in the observed range of $10^{52.8} - 10^{53.3}\mathrm{cm}^{-3}$ can be reproduced with densities in the range $10^9 - 10^{10.7}\mathrm{cm}^{-3}$ for coronae at temperatures of $10^6 - 10^7$K.

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Evidence for Strong Differential Rotation in Li-depleted Fast Rotating F-stars

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We report the detection of strong differential rotation on ten fast rotating ($v \sin i > 10\,\mathrm{km\,s}^{-1}$) stars of spectral types F0 – G0 using the Fourier Transform Method, in three cases we find $\alpha > 20\,\%$. Among the six differential rotators with $v \sin i > 15\,\mathrm{km\,s}^{-1}$, five have Li abundances of $\log\epsilon(\mathrm{Li}) < 1.5$, for one object no Li abundance is available to our knowledge. No differentially rotating star with high Li abundance was found, although the average Li abundance of fast rotators in the literature is $\log\epsilon(\mathrm{Li}) > 2.0$. Our results suggest that Li-depleted fast rotators tend to show differential rotation. Interpreting high rotational velocity as indicator of youth, this finding supports the idea of the connection between mixing processes and differential rotation during magnetic breaking in F-stars.

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Chandra X-ray Observation of the Orion Nebula Cluster. I Detection, Identification and Determination of X-ray Luminosities

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In this first of two companion papers on the Orion Nebula Cluster (ONC), we present our analysis of a 63 Ksec *Chandra* HRC-I observation that yielded 742 X-ray detections within the $30' \times 30'$ field of view. To facilitate our interpretation of the X-ray image, here we collect a multi-wavelength catalog of nearly 2900 known objects in the region by combining 17 different catalogs from the recent literature. We define two reference groups: an *infrared sample*, containing all objects detected in the K band, and an *optical sample* comprising low extinction, well characterized ONC members. We show for both samples that field object contamination is generally low.

Our X-ray sources are primarily low mass ONC members. The detection rate for optical sample stars increases monotonically with stellar mass from zero at the brown dwarf limit to $\sim 100\%$ for the most massive stars but shows a pronounced dip between 2 and 10 solar masses.

We determine L_X and L_X/L_{bol} for all stars in our *optical sample* and utilize this information in our companion paper to study correlations between X-ray activity and other stellar parameters.

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Chandra X-ray Observation of the Orion Nebula Cluster. II Relationship Between X-ray Activity Indicators and Stellar Parameters

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Using the results of our first paper on the *Chandra* HRC observation of the Orion Nebula Cluster (ONC), here we explore the relation between the coronal activity of its 1-Myr-old pre-main sequence population and stellar parameters. We find that median X-ray luminosities of low mass stars ($M/M_{\odot} < 3$) increase with increasing mass and decreasing stellar age. Brown dwarfs ($0.03 < M/M_{\odot} < 0.08$) follow the same trend with mass. From $M \sim 0.1$ to $M \sim 0.5\ M_{\odot}$, median L_X/L_{bol} values increase by about half an order of magnitude and then remain constant at $\sim 10^{-3.5}$ for the mass range from 0.5 to 3.0 $M/M_{\odot}$. In these same two mass ranges, L_X/L_{bol} remains roughly constant with age, until it drops by more than two orders of magnitudes at the epoch when $\sim 2-4M_{\odot}$ stars are expected to become fully radiative.

We find a dependence of L_X and L_X/L_{bol} on circumstellar accretion indicators and suggest three possible hypotheses for its origin. In spite of improved X-ray and rotational data, correlations between activity indicators and rotation remain elusive for these stars, possibly indicating that stars for which rotational periods have been measured have reached some saturation level.

Our study of X-ray activity vs. stellar mass leads us to propose that the few HRC X-ray sources not associated with any optical/infrared counterpart trace a yet to be discovered stellar population of deeply embedded, relatively massive ONC members.

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High-resolution Spectroscopic Monitoring of SV Cam I. Orbits, Absolute Masses and Radii of the Components

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This study is a first part of an analysis of newly obtained time series of high-resolution Echelle spectra of the RS CVn star SV Cam. We investigate the radial velocity variations of the spectroscopic binary and derive an improved orbital solution for both components. The results allow us to estimate the masses of the primary to 1.1 $M_\odot$ and of the secondary to 0.7 $M_\odot$ and, from a previous analysis of the light curve of SV Cam, we derive the stellar radii of 1.18 $R_\odot$ for the primary and of 0.76 $R_\odot$ for the secondary. From a compilation of eclipse minimum times spanning a period of over 100 years we compute the orbital elements of a hypothetical third body belonging to the SV Cam system. We obtain a period of 52.3 years which is slightly longer than derived by authors before and a much higher eccentricity of at least 0.42. From the mass function there follows a lower limit to the third body mass 0f 0.17 $M_\odot$. The applied procedure also provides an optimized period of eclipses of 0.59307180 days.

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Orbital Motion in Symbiotic Mira Systems

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We present new spectropolarimetry of the Raman lines for seven symbiotic Miras, combine it with earlier data and review the polarimetric changes. All systems show slow and usually steady angular variations which are most easily interpreted as a reflection of the orbital motion. We measure angular rotation rates of typically 1 to 5°/yr. Small position angle changes are seen in Hen 2-106 and RR Tel, while Hen 2-38 and Hen 2-127 have high rotation rates. Although our data base spreads over a time span of almost 10 years, we still cover only a fraction of a typical D-type orbit. Since we expect elliptical orbits, it is too early to extrapolate to an orbital period for any individual object. In a statistical sense, however, our mean angular rotation rate shows that an average orbital period for a symbiotic Mira is 150 years. We also determine the position angle of the binary axes as projected onto the sky. Our polarimetry finally suggests that the binary axes of the systems V1016 Cyg and Hen 2-38 are not far from parallel to the line of sight (conjunction), whereas the binary axes of RR Tel and AS 210 lie approximately at an angle of 90° to the line of sight.

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Measuring Starspot Temperature from Line Depth Ratios I.The Method

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Gray and collaborators have recently demonstrated that line-depth ratios are a powerful tool for temperature discrimination, able to resolve differences $\leq$ 10 K. The method has been applied to detect temperature variations in the 5-15 K range due to activity cycles (e.g. Gray et al. 1996a, 1996b) or to rotation modulation produced by large surface features, called "star-patches", like that detected in ξ Boo A by Toner & Gray (1988). Cool starspots of a few tenths of the stellar surface produce bumps in a line profile, which migrate through the line profile allowing Doppler-imaging in fast rotating stars. In the hypothesis that in slowly-rotating stars the passage of dark spots produces modulation of the center line depth of different amount in lines of different sensitivity to temperature, we have made test observations on three active binaries of the RS CVn type. Based on observations made at the Catania Astrophysical Observatory

at a resolution R = 14 000, we show that line-depth ratios can be effectively used to determine spot temperatures of active binary systems. Using, on average, ten line pairs, selected in the 6100-6300 Å wavelength range, with the help of observations of 30 main sequence and giant stars, we have derived a calibration relation of line-depth ratios (LDR) in an absolute temperature scale, taking into account the gravity effect in the calibration relation. Single LDRs converted to temperature through the calibration relations have led to clear rotational modulation of the average surface temperature with amplitudes of 177 K, 119 K, and 127 K for VY Ari, IM Peg and HK Lac, with average estimated errors of about 10 K. We show that the observed temperature variation amplitude allows us to define a minimum fractional spotted area coverage as a function of spot-photosphere temperature ratio. Adopting the maximum value of average temperature, determined from the LDRs, as that of the unspotted photosphere, we computed the average spot temperature corresponding to the minimum spot coverage. Although not univocally constrained, the temperature difference ($\Delta T = T_{\rm ph} - T_{\rm sp}$) obtained for the three systems, $\Delta T = 890$ K for VY Ari, $\Delta T = 750$ K for IM Peg, and $\Delta T = 810$ K for HK Lac, are in good agreement with values derived with other methods. **References:** Gray, D. F., Baliunas, S. L., Lockwood, G. W., & Skiff, B. A. 1996a, ApJ, 456, 365; Gray, D. F., Baliunas, S. L., Lockwood, G. W., & Skiff, B. A. 1996b, ApJ, 465, 945; Toner, C. G., & Gray, D. F. 1988, ApJ, 334, 1008

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Flare Heating in Stellar Coronae

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An open question in the field of solar and stellar astrophysics is the source of heating that causes stellar coronae to reach temperatures of millions of degrees. One possibility is that the coronae are heated by a large number of small flares. On the Sun, flares with energies as low as those of microflares are distributed with energy as a power law of the form $\frac{dN}{dE} \propto E^{-\alpha}$ with $\alpha \approx 1.8$, and α appears to increase to values 2.2-2.7 for flares of lower energy. If the slope exceeds the critical value of 2, then in principle the entire coronal energy input may be ascribed to flares that are increasingly less energetic, but are more numerous. Previous analyses of flares in light-curves of active stars have shown that this index is generally > 2, though it may be as low as 1.6 when strong flares alone are considered. Here we investigate the contribution of very weak flares, covering the milliflare energy range, to the coronal luminosity of low-mass active stars. We analyze *EUVE*/DS events data from FK Aqr, V1054 Oph, and AD Leo and conclude that in all these cases the coronal emission is dominated by flares to such an extent that in some cases the entire emission may be ascribed to flare heating. We have developed a new method to directly model for the first time stochastically produced flare emission, including undetectable flares, and their effects on the observed photon arrival times. We find that $\alpha_{\rm FK\,Aqr} = 2.60 \pm 0.34$, $\alpha_{\rm V1054\,Oph} = 2.74 \pm 0.35$, $\alpha_{\rm AD\,Leo} = 2.03 - 2.32$, and that the flare component accounts for a large fraction (generally $> 50\%$) of the total flux.

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Are Coronae of Magnetically Active Stars Heated by Flares? II. EUV and X-Ray Flare Statistics and the Differential Emission Measure Distribution

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We investigate the EUV and X-ray flare rate distribution in radiated energy of the late-type active star AD Leo. Occurrence rates of *solar* flares have previously been found to be distributed in energy according to a power law, $dN/dE \propto E^{-\alpha}$, with a power-law index α in the range 1.5−2.6. If $\alpha \geq 2$, then an extrapolation of the flare distribution to low flare energies may be sufficient to heat the complete observable X-ray/EUV corona.

We have obtained long observations of AD Leo with the *EUVE* and *BeppoSAX* satellites. Numerous flares have been detected, ranging over almost two orders of magnitude in their radiated energy. We compare the observed light curves with light curves synthesized from model flares that are distributed in energy according to a power law with selectable index α. Two methods are applied, the first comparing flux distributions of the binned data, and the second using the distributions of photon arrival time differences in the unbinned data (for *EUVE*). Subsets of the light curves are tested individually, and the quiescent flux has optionally been treated as a superposition of flares from the same flare distribution. We find acceptable α values between 2.0−2.5 for the *EUVE* DS and the *BeppoSAX* LECS data. Some variation is found depending on whether or not a strong and long-lasting flare occurring in the *EUVE* data is included. The *BeppoSAX* MECS data indicate a somewhat shallower energy distribution (smaller α) than the simultaneously observed LECS data, which is attributed to the harder range of sensitivity of the MECS detector and the increasing peak temperatures of flares with increasing total (radiative) energy. The results suggest that flares can play an important role in the energy release of this active corona. We discuss caveats related to time variability, total energy, and multiple power-law distributions. Studying the limiting case of a corona that is entirely heated by a population of flares, we derive an expression for the time-averaged coronal differential emission measure distribution (DEM) that can be used as a diagnostic for the flare energy distribution. The shape of the analytical DEM agrees with previously published DEMs from observations of active stars.

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A Transient Heating Model for Coronal Structure and Dynamics

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A wealth of observational evidence for flows and intensity variations in nonflaring coronal loops leads to the conclusion that coronal heating is intrinsically unsteady and concentrated near the chromosphere. We have investigated the hydrodynamic behavior of coronal loops undergoing transient heating with 1-D numerical simulations, in which the timescale assumed for the heating variations (3000 s) is comparable to the coronal radiative cooling time and the assumed heating location and scale height (10 Mm) are consistent with the values derived from TRACE studies. The model loops represent typical active-region loops: 40 to 80 Mm in length, reaching peak temperatures up to 6 MK. We use *ARGOS*, our state-of-the-art numerical code with adaptive mesh refinement, in order to resolve adequately the dynamic chromospheric-coronal transition region sections of the loop. The major new results from our work are the following. (1) During much of the cooling phase, the loops exhibit densities significantly larger than those predicted by the well-known loop scaling laws, thus potentially explaining recent TRACE observations of overdense loops. (2) Throughout the transient heating interval, downflows appear in the lower transition region (T $\sim$ 0.1 MK) whose key signature would be persistent, redshifted UV and EUV line emission, as have long been observed. (3) Strongly unequal heating in the two legs of the loop drives siphon flows from the more strongly heated footpoint to the other end, thus explaining the substantial bulk flows in loops recently observed by CDS and SUMER. We discuss the implications of our studies for the physical origins of coronal heating and related dynamic phenomena.

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Time Series Photometric Spot Modelling V. Phase Coherence of Spots on UZ Librae

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We present spot models for nine years of continuous VI_C photometry of UZ Lib from 1993–2001. The relatively stable double-humped light curve shape suggests extreme phase coherence. From the spot-modelling analysis, we found that the major spots or spot groups are always located on the hemisphere facing the secondary star and exactly in the opposite hemisphere anti-facing the secondary. Several single-humped light curves and our suggested binary scenario rule out a pure ellipsoidal variability as the cause of the double-humped light curve shape. We try to explain this preferred spot pattern with a magnetic-field structure that connects the two components, as suggested earlier for RS CVn stars in general. A possible 4.8 years spot cycle is found from the long-term brightness variations but needs confirmation. We rediscuss the basic astrophysical data of UZ Lib. The Hipparcos parallax is likely wrong, a possible reason could be that UZ Lib is e.g., a triple system.

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Solar Abstracts

Do Dynamo-Waves Propagate Along Isorotation Surfaces?

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It is shown that the basic rule of the dynamo theory on the propagation of dynamo-waves along surfaces of constant angular velocity is restricted to the case of isotropic magnetic diffusion. The influence of rotation on convective turbulence induces an anisotropy in the eddy diffusivity. The anisotropy makes the direction of travel of the dynamo wave deviate from the isorotation surfaces. The deviation is towards the equator for solar conditions. This finding may help to resolve the old problem of solar dynamo theory concerning the incompatibility between the helioseismological rotation law and equatorward migration of solar activity. A qualitative explanation for the inclined propagation is suggested. The derived properties of the dynamo waves are illustrated by 2D dynamo models in spherical geometry. The model with anisotropic diffusion shows a pronounced equatorial drift of toroidal fields even with a depth independent rotation.

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Enhancement of the Helium Resonance Lines in the Solar Atmosphere by Suprathermal Electron Excitation I: Non-thermal Transport of Helium Ions

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Models of the solar transition region made from lines other than those of helium cannot account for the strength of the helium lines. However, the collisional excitation rates of the helium resonance lines are unusually sensitive to the energy of the exciting electrons. Non-thermal motions in the transition region could drive slowly-ionizing helium ions rapidly through the steep temperature gradient, exposing them to excitation by electrons characteristic of higher temperatures than those describing their ionization state. We present the results of calculations which use a more physical representation of the lifetimes of the ground states of He I and He II than was adopted in earlier work on this process. New emission measure distributions are used to calculate the temperature variation with height. The results show that non-thermal motions can lead to enhancements of the He I and He II resonance line intensities by factors that are comparable with those required. Excitation by non-Maxwellian electron distributions would *reduce* the effects of non-thermal transport. The effects of non-thermal motions are more consistent with the observed spatial distribution

of helium emission than are those of excitation by non-Maxwellian electron distributions alone. In particular, they account better for the observed line intensity ratio $I(537.0\ \text{Å})/I(584.3\ \text{Å})$, and its variation with location.

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On the Theory of MAG Waves and a Comparison with Sunspot Observations from CDS/SoHO

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We examine the influence of non-adiabatic effects on the modes of an isothermal stratified magnetic atmosphere. We present new solutions for magneto-acoustic-gravity(or MAG) waves in the presence of a radiative heat exchange based on Newton's law of cooling. An analytic expression for the dispersion relation is derived, which allows the effect of a weak magnetic field on the modes to be studied. The insight so gained proves useful in extending the computations to the moderate–high field case. In the second part we present observations of two sunspots obtained in the EUV wavelength range with the Coronal Diagnostic Spectrometer (CDS) on SoHO. We examine the time series for the line intensities and relative velocities and calculate their power spectra using wavelet transforms. We find oscillations in the chromosphere and transition region above the sunspots in the temperature range log T = 4.6-5.4 K. Most of the spectral power above the umbra is contained in the 5-7 mHz frequency range. When the CDS slit crosses the sunspot umbra a clear 3 min oscillation is observed. The observed oscillation frequencies are compared with the computed frequencies and the observations are interpreted in terms of the slow magneto-acoustic waves.

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Low-Mass and Substellar Abstracts

A False Planet Around HD 192263

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We present new high-precision Strömgren photometry and Ca II H and K spectrophotometry of HD 192263. Based on radial velocity variations detected previously by two groups, this K2 V star was thought to host a $0.75 M_{\rm Jup}$ (minimum mass) planetary companion in a 24-day orbit. Our photometric observations reveal periodic variations that match the purported planetary orbital period, while the Ca II H and K emission fluxes are modulated on half the planetary period. This suggests that rotational modulation of the visibility of stellar surface activity is the source of the observed radial velocity variations. Therefore, HD 192263 should be removed from lists of stars with well-established planetary companions unless further observations and analysis can support the existence of the planet in spite of the star's intrinsic variations.

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For preprints via ftp or WWW: http://schwab.tsuniv.edu/papers/apj/hd192263/hd192263.html

Job Opening

Postdoctoral Research Assistant
Solar Physics: Transition Region & Coronal Dynamics
Armagh Observatory (N. Ireland)

Applications are invited for a three year postdoctoral research assistantship (PDRA) in Solar Physics to be held at Armagh Observatory beginning November 2002 or as soon as possible thereafter. The PDRA's work activities will be directed towards an extensive data reduction/interpretation and/or modelling programme relating to a range of transient phenomena and their interrelationships. A knowledge of MHD and atomic processes would be an advantage, although not essential, as the project can be directed more towards observations depending on the PDRA's relevant experience.

Further information about Armagh Observatory, and in particular the current Solar Physics research programme, may be obtained by consulting the Observatory's web-site:

http://star.arm.ac.uk

and in particular the preprint WEB page or via email to Gerry Doyle (jgd@star.arm.ac.uk).

The closing date for applications is 11 October 2002. This project is funded by the Programme for Research in Third Level Institutions under the National Development Plan with assistance from the European Regional Development Fund. The work will involve use of super-computing facilities via the Irish Grid. Prospective applicants should obtain an application pack from the Administrator or it may be downloaded from
http://star.arm.ac.uk/~jgd/outgoing/JOB/.

The completed application form, together with a full curriculum vitae and bibliography should be sent to:

The Administrator, Armagh Observatory
College Hill, Armagh BT61 9DG, N. Ireland

Tel. +44-(0)28-3752-2928
Fax. +44-(0)28-3752-7174
email lfy@star.arm.ac.uk

Applicants are asked to ensure that references from three referees should also reach the Administrator by the same date.

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.***