COOLNEWS

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Stellar Abstracts

Detection of X-ray Resonance Scattering in Active Stellar Coronae

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An analysis of Lyman series lines arising from hydrogen-like oxygen and neon ions in the coronae of the active RS CVn-type binaries II Peg and IM Peg, observed using the *Chandra* High Resolution Transmission Grating Spectrograph, shows significant decrements in the Lyα/Lyβ ratios as compared with theoretical predictions and with the same ratios observed in similar active binaries. We interpret these decrements in terms of resonance scattering of line photons out of the line-of-sight; these observations present the first strong evidence for this effect in active stellar coronae. The net line photon loss implies a non-uniform and asymmetric surface distribution of emitting structures on these stars. Escape probability arguments, together with the observed line ratios and estimates of the emitting plasma density, imply typical line-of-sight sizes of the coronal structures that dominate the X-ray emission of 10^{10} cm at temperatures of 3×10^6 K and of 10^8 cm at 10^7 K. These sizes are an order of magnitude larger than predicted by simple quasi-static coronal loops models, but are still very small compared to the several 10^{11} cm radii of the underlying stars.

To appear in ApJ Letters

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KH 15D: A Spectroscopic Binary

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We present the results of a high-resolution spectroscopic monitoring program of the eclipsing pre–main-sequence star KH 15D that reveal it to be a single-line spectroscopic binary. We find that the best-fit Keplerian model has a period

P = 48.38 days, which is nearly identical to the photometric period. Thus, we find the best explanation for the periodic dimming of KH 15D is that the binary motion carries the currently visible star alternately above and behind the edge of an obscuring cloud. The data are consistent with the models involving an inclined circumbinary disk, as recently proposed by Winn et al. (2004) and Chiang & Murray-Clay (2004). We show that the mass ratio expected from models of PMS evolution, together with the mass constraints for the visible star, restrict the orbital eccentricity to $0.68 \leq e \leq 0.80$ and the mass function to $0.125 \leq F_M / \sin^3 i \leq 0.5$ $M_\odot$.

Accepted by AJ

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Editor's Note: The above abstract is being cross-listed with the Star Formation Newsletter.

X-ray Spectroscopy of the Unsteady Quiescent Corona of AD Leo with *Chandra*

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We present the analysis and interpretation of an observation of the flare star AD Leo (dM3e) with the Low-Energy Transmission Grating of *Chandra*. The high resolution X-ray spectrum – dominated by emission lines from O VII–VIII, Ne IX–X, and Fe XVII–Fe XIX – allowed us to infer the plasma emission measure distribution (EMD) vs. temperature, and the abundances of individual elements in the corona of this magnetically-active star, during a typical state characterized by significant variability but no evident flaring event. We have also measured plasma densities at various temperatures using spectroscopic diagnostics provided by He-like triplets and Fe XXI lines. We show that the present EMD is similar, in terms of overall shape and temperature of the peak, to those previously obtained from EUVE spectra during quiescent and flaring states confirming the long-term stability of the corona of AD Leo. At variance with the case of other active stars, the EMD of AD Leo is characterized by a significantly shallower slope, compatible with that predicted by static models of isobaric loops with constant cross-section and uniform heating. We discuss such coronal modeling to infer the average properties of the corona in terms of loop populations, including estimates of the surface filling factor derived by comparison between the model and the observed EMD. We also show that the EMD is compatible with the model of a corona continuously heated by flares, which predicts an EMD slope slightly steeper than observed, but that can be accommodated by observational uncertainties. The coronal composition is such that the element abundances, relative to solar values, tend to increase with the First Ionization Potential, with few exceptions. The line to continuum ratios suggest a nearly solar metallicity, a result difficult to reconcile with previous determinations based on global fitting of X-ray spectra.

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A Detailed Study of Opacity in the Upper Atmosphere of Proxima Centauri

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We present FUV and UV spectroscopic observations of Proxima Centauri obtained as part of our continued investigation into the optically thin approximation assumed for the transition regions of late–type stars. Significant opacity is found in the CIII lines during both the quiescent and flaring states of Prox Cen, with up to 70% of the expected flux being lost in the latter. Our findings cast some doubt on the suitability of the CIII 977 Å line for estimating the electron density in stellar atmospheres. However, the opacity has no significant effect on the observed line widths. We calculate optical depths for homogeneous and inhomogeneous geometries, and estimate an electron density of

6×10^{10} cm^{-3} for the transition region using the OIV line ratios at 1400 Å. The combination of electron density and optical depth indicates path lengths as low as ≈ 10 km, which are in excellent agreement with estimates of the small-scale structure seen in the solar transition region.

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For preprints via ftp or WWW: ftp://star.pst.qub.ac.uk/pub/dc/proxcen_preprint.ps

X-ray Astronomy of Stellar Coronae

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X-ray emission from stars in the cool half of the Hertzsprung-Russell diagram is generally attributed to the presence of a magnetic corona that contains plasma at temperatures exceeding 1 million K. Coronae are ubiquitous among these stars, yet many fundamental mechanisms operating in their magnetic fields still elude an interpretation through a detailed physical description. Stellar X-ray astronomy is therefore contributing toward a deeper understanding of the generation of magnetic fields in magnetohydrodynamic dynamos, the release of energy in tenuous astrophysical plasmas through various plasma-physical processes, and the interactions of high-energy radiation with the stellar environment. Stellar X-ray emission also provides important diagnostics to study the structure and evolution of stellar magnetic fields from the first days of a protostellar life to the latest stages of stellar evolution among giants and supergiants. The discipline of stellar coronal X-ray astronomy has now reached a level of sophistication that makes tests of advanced theories in stellar physics possible. This development is based on the rapidly advancing instrumental possibilities that today allow us to obtain images with sub-arcsecond resolution and spectra with resolving powers exceeding 1000. High-resolution X-ray spectroscopy has, in fact, opened new windows into astrophysical sources, and has played a fundamental role in coronal research.
The present article reviews the development and current status of various topics in the X-ray astronomy of stellar coronae, focusing on observational results and on theoretical aspects relevant to our understanding of coronal magnetic structure and evolution.

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On the Determination of Oxygen Abundances in Chromospherically Active Stars

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We discuss oxygen abundances derived from [O I] λ6300 and the O I triplet in stars spanning a wide range in chromospheric activity level, and show that these two indicators yield increasingly discrepant results with higher chromospheric/coronal activity measures. While the forbidden and permitted lines give fairly consistent results for solar-type disk dwarfs, spuriously high O I triplet abundances are observed in young Hyades and Pleiades stars, as well as in individual components of RS CVn binaries (up to 1.8 dex). The distinct behaviour of the [O I]-based abundances which consistently remain near-solar suggests that this phenomenon mostly results from large departures from LTE affecting the O I triplet at high activity level that are currently unaccounted for, but also possibly from a failure to adequately model the atmospheres of K-type stars. These results suggest that some caution should be exercised when interpreting oxygen abundances in active binaries or young open cluster stars.

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Are Coronae of Late Type Stars Made of Solar-like Structures? The F_X-HR Diagram and the Pressure-Temperature Correlation

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This work is dedicated to the solar-stellar connection, i.e. the close similarity of the Sun and the late-type stars; in particular this work shows that stellar coronae can be composed of *X-ray emitting* structures similar to those present in the solar corona. To this end we use a large set of ROSAT/PSPC observations of late-type-stars of all spectral types and activity levels, and a large set of solar X-ray data collected with Yohkoh/SXT.

Solar data have been analyzed and formatted to study the Sun as an X-ray star; they include observations of the solar corona at various phases of the cycle and data on various kinds of *X-ray* coronal structures, from flares to the background corona, i.e. the most quiet regions.

We use the X-ray surface flux (F_X) vs. spectral hardness ratio (HR) diagram as a fundamental tool for our study. We find that F_X is strongly correlated to HR in stellar coronae, in the solar corona at all phases of the cycle, and in the individual solar coronal structures; all the above follow the same law. Schmitt found the same correlation in stellar coronae.

We therefore claim that coronae of late type stars are formed with *X-ray* structures very similar to the solar ones, since their behavior is identical to that of the solar coronal structures and of the whole solar corona. The spatial location of the *X-ray* structures on the star, however, can be very different than on the Sun.

In this scenario, the fraction of the stellar surface covered with active regions and with their bright cores increases with activity; the most active stars are brighter and hotter than if they were entirely covered with active regions so they can be explained only with the additional presence of several flares (or flare-like structures) at any time.

On the basis of the F_X vs. HR correlation, *corresponding to* $F_X \propto T^6$, we then derive a set of new laws relating the temperature, pressure, volumetric heating and characteristic loop length of the coronal plasma, on all the late type stars. Also, individual solar coronal structures and the whole solar corona, follow the same laws. These laws also agree with recent findings of higher plasma density at higher temperatures in stellar coronae.

We claim that the strong correlation between surface flux and temperature and the laws mentioned above are just the effect of more fundamental physical mechanisms driving the coronal structures of all the late-type stars from the emergence of new magnetic structures to their dispersal and dissipation.

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Solar Abstracts

Dual Flows with Supersonic Velocities in the Sunspot Transition Region

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Observations of sunspot transition region lines that deviate significantly from a Gaussian shape are presented. Attention is given to "dual flows", a line profile phenomenon where two distinct velocities are observed within the same spatial resolution element. In five out of twelve sunspots we observe dual flows. Several emission line profiles are well represented by two Gaussian line components, one with a subsonic- and one with a supersonic line-of-sight velocity.

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Chromospheric Oscillations in an Equatorial Coronal Hole

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We report phase-difference and travel-time analyses of propagating chromospheric oscillations in and around an equatorial coronal hole as observed by the *Transition Region and Coronal Explorer*. Our results suggest a significant change in atmospheric conditions at the base of the chromosphere inside the coronal hole relative to its boundary and quiet Sun regions.

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AFS Dynamic Evolution During the Emergence of an Active Region

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Using data acquired during an observational campaign carried out at the THEMIS telescope in IPM mode, coordinated with other ground- and space-based instruments (IOACT, TRACE, EIT/SOHO, MDI/SOHO), we have analyzed the first evolutionary phases of a recurrent active region (NOAA 10050), in order to study the morphology and dynamics of its magnetic structures during their emergence and early development. The main result obtained from this analysis concerns the dynamic evolution of the arch filament system (AFS) crossing the polarity inversion line: the line of sight velocities determined from Doppler measurements confirm that the loops forming the AFS show an upward motion at their tops and a downward motion at their extremities, but also indicate that the upward motion decreases while the active region develops. Moreover, it has been found that, within the limits of the temporal cadence and spatial resolution of the instruments used, the first evidences of the active region formation are initially observed in the transition region and lower corona, and later on (i.e. after about 6 hours) in the inner layers (chromosphere and photosphere). Another interesting result concerns the analysis of the magnetograms, indicating that the initial increase in the magnetic flux seems to be synchronous with the active region appearance in the transition region and lower corona, and that the rate of increase of the magnetic flux during the active region formation is not constant, but is steeper at the beginning (i.e. during the first 150 hours) than in the following period. All these results may indicate the presence of some mechanism which decelerates the magnetic flux emergence as more and more flux tubes rise towards higher atmospheric layers. Finally, we would like to stress the observed asymmetries between the preceding and the following sides of NOAA 10050: the p-side is more extented than the f-side, the p-side moves forward from the initial outbreak position much faster than the f-side recedes; the AFS f-side exhibit s higher downflows than the p-side. Accepted by A&A *For preprints contact*: dspadaro@ct.astro.it

The Sun as an X-ray Star: Active Region Evolution, Rotational Modulation, and Implications for Stellar X-ray Variability

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We study the contribution of an active region and its core to the luminosity and the spectrum of the Sun in the X-ray band and to the relevant solar emission measure vs. temperature distribution, EM(T). We also study the relevant changes in the course of four solar rotations, and the solar rotational modulation due to this active region, the only one present at that time.

To this end, we have used a large sample of full-disk Yohkoh/SXT observations taken between July and October 1996, covering most of the active region evolution. From the Yohkoh/SXT data we have synthesized the X-ray spectra of the whole solar corona, and the focal plane data as they would be collected with Rosat/PSPC, XMM-Newton/EPIC and Chandra/ACIS. This work is part of a project to study the Sun as an X-ray star, using the solar data as a guide and a template for stellar observations.

We found that the active region contributes significantly to the X-ray spectrum of the Sun mainly during the first month of its evolution. The rotational modulation due to the active region causes a significant variability of the average X-ray flux, with only moderate spectral variation, in the pass-bands of Rosat/PSPC, XMM-Newton/EPIC and Chandra/ACIS.

We investigated the characteristics of the X-ray variability due to the rotational modulation, to the solar cycle, and to flares together with the possible implications on stellar X-ray variability. We derived the diagram of X-ray surface flux vs. spectral hardness ratio in the Rosat/PSPC band; we studied the variability due to the solar cycle and to the rotational modulation and we found that both lead to the same correlation between F_{pspc} and HR_{pspc} with a very steep slope. The variability due to the evolution of flares again produces a correlation between F_{pspc} and HR_{pspc} but with a much flatter slope than in the other two cases. Analogous results have been found when analyzing data in the format of XMM-Newton/EPIC and Chandra/ACIS.

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Low-Mass and Substellar Abstracts

The Effect of Evaporation on the Evolution of Close-in Giant Planets

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We include the effect of evaporation in our evolutionary calculations of close-in giant planets, based on a recent model for thermal evaporation taking into account the XUV flux of the parent star (Lammer et al. 2003). Our analysis leads to the existence of a critical mass for a given orbital distance $m_{\rm crit}(a)$ below which the evaporation timescale becomes shorter than the thermal timescale of the planet. For planets with initial masses below $m_{\rm crit}$, evaporation leads to a rapid expansion of the outer layers and of the total planetary radius, speeding up the evaporation process. Consequently, the planet does not survive as long as estimated by a simple application of mass loss rates without following consistently its evolution. We find out that the transit planet HD 209458b might be in such a dramatic phase, although with an extremely small probability. As a consequence, we predict that, after a certain time, only planets above a value $m_{\rm crit}(a)$ should be present at an orbital distance a of a star. For planets with initial masses above $m_{\rm crit}$, evaporation does not affect the evolution of the radius with time.

Accepted by A&A Letter

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Rotation Periods for Very Low Mass Stars in the Pleiades

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We present the results of a photometric monitoring campaign for very low mass (VLM) members of the Pleiades. Periodic photometric variability was detected for nine VLM stars with masses between 0.08 and $0.25\,M_{\odot}$. These

variations are most likely caused by co-rotating, magnetically induced spots. In comparison with solar-mass stars, the photometric amplitudes are very low (< 0.04 mag), implying that either the fraction of the spot-covered area, the asymmetry of the spot distribution, or the contrast between spots and photospheric environment decreases with mass. From our lightcurves, there is evidence for temporal evolution of the spot patterns on timescales of about two weeks. The rotation periods range from 2.9 h to 40 h and tend to increase linearly with mass. Compared with more massive stars, we clearly see a lack of slow rotators among VLM objects. The rotational evolution of VLM stars is investigated by evolving the previously published periods for very young objects (Scholz & Eislöffel 2004) forward in time, and comparing them with those observed here in the Pleiades. We find that the combination of spin-up by pre-main sequence contraction and exponential angular momentum loss through stellar winds is able to reproduce the observed period distribution in the Pleiades. This result may be explained as a consequence of convective, small-scale magnetic fields.

Accepted by A&A

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The HARPS Search for Southern Extra-solar Planets I. HD 330075 b: A New "Hot Jupiter"

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We report on the first extra-solar planet discovered with the brand new HARPS instrument. The planet is a typical "hot Jupiter" with $m_2 \sin i = 0.62\,\mathrm{M}_{Jup}$ and an orbital period of 3.39 days, but from the photometric follow-up of its parent star HD 330075 we can exclude the presence of a transit. The induced radial-velocity variations exceed $100\,\mathrm{m\,s^{-1}}$ in semi-amplitude and are easily detected by state-of-the-art spectro-velocimeters. Nevertheless, the faint magnitude of the parent star ($V = 9.36$) benefits from the efficient instrument: With HARPS less than 10 observing nights and 3 hours of *total* integration time were needed to discover the planet and characterize its orbit.

The orbital parameters determined from the observations made during the first HARPS run in July 2003 have been confirmed by **7** additional observations carried out in February 2004. The bisector analysis and a photometric follow-up give no hint for activity-induced radial-velocity variations, indicating that the velocity curve is best explained by the presence of a low-mass companion to the star. In this paper we present a set of 21 measurements of excellent quality with weighted *rms* as low as $2.0\,\mathrm{m\,s^{-1}}$. These measurements lead to a well defined orbit and consequently to the precise orbital parameters determination of the extra-solar planet HD 330075 b.

Accepted by A&A

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The Brown Dwarf Desert at 75-1200 AU

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We present results of a comprehensive infrared coronagraphic search for substellar companions to nearby stars. The research consisted of: 1.) a 178 star survey at Steward and Lick Observatories, with optical followup from Keck Observatory, capable of detecting companions with masses greater than 30 $M_{Jupiter}$, and semi-major axes between about 140 to 1200 AU. 2.) a 102 star survey using the Keck telescope, capable of detecting extrasolar brown dwarfs

and planets typically more massive than 10 $M_{Jupiter}$, with semi-major axes between about 75 and 300 AU.

Only one brown dwarf companion was detected, and zero planets. The frequency of brown dwarf companions to G, K & M stars orbiting between 75 and 300 AU is measured to be 1±1%, the most precise measurement of this quantity to date. The frequency of massive ($> 30M_{Jupiter}$) brown dwarf companions at 120-1200 AU is found to be $f = 0.7 \pm 0.7\%$. The frequency of giant planet companions with masses between 5 and 10 $M_{Jupiter}$ orbiting between 75 and 300 AU is measured here for the first time to be no more than $\sim 3\%$.

Together with other surveys that encompass a wide range of orbital separations, these results imply that substellar objects with masses between 12 and 75 $M_{Jupiter}$ form only rarely as companions to stars. Theories of star formation which could explain these data are only now beginning to emerge.

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New Neighbours. III. 21 New Companions to Nearby Dwarfs, Discovered with Adaptive Optics

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We present some results of a CFHT adaptive optics search for companions to nearby dwarfs. We identify 21 new components in solar neighbourhood systems, of which 13 were found while surveying a volume-limited sample of M dwarfs within 12 pc. We are obtaining complete observations for this subsample, to derive unbiased multiplicity statistics for the very-low-mass disk population. Additionally, we resolve for the first time 6 known spectroscopic or astrometric binaries, for a total of 27 newly resolved companions. A fair fraction of the new binaries has favourable parameters for accurate mass determinations.
The newly resolved companion of Gl 120.1C had an apparent spectroscopic minimum mass in the brown-dwarf range, and it contributed to the statistical evidence that a few percent of solar type stars might have close-in brown-dwarf companions. We find that Gl 120.1C actually is an unrecognised double-lined spectroscopic pair. Its radial-velocity amplitude had therefore been strongly underestimated by Duquennoy & Mayor 1991, and it does not truly belong to their sample of single-lined systems with minimum spectroscopic mass below the substellar limit.
We also present the first direct detection of Gl 494B, an astrometric brown-dwarf candidate. Its luminosity does straddle the substellar limit, and it is a brown dwarf if its age is less than ~300 Myr. A few more years of observations will ascertain its mass and status from first principles.

Accepted by A&A

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Job Openings (PhD Studentships)

PhD Student Fellowships

Solar System Physics

Max Planck Inst. for Aeronomy; Univ. of Braunschweig; Univ. of Goettingen

Germany

The "International Max Planck Research School on Physical Processes in the Solar System and Beyond" at the Max Planck Institute for Aeronomy in Katlenburg-Lindau, and the Universities of Braunschweig and Goettingen, Germany, offers excellent research possibilities for students to obtain a PhD degree in a 3-years graduate program.

The program covers the full range of physics inherent in the field of solar system science from geophysics and planetary physics to solar physics as well as the underlying fundamental physics.

High-profile space missions, outstanding projects for ground- based instruments and data analysis, as well as theoretical and extensive numerical modeling provide a wide range of research possibilities for PhD students.

A prerequisite is a diploma or a master of science degree in physics.

The next PhD program will start on 1 January 2005, review of application begins on 1 July 2004. Successful applicants will receive adequate financial support.

For details about the Research School and the application material visit http://www.solar-system-school.de or email to info@solar-system-school.de

Address applications to

Dr. Dieter Schmitt Coordinator of IMPRS on Solar System Physics Max Planck Institute for Aeronomy Max-Planck-Str. 2 37191 Katlenburg-Lindau Germany Tel: +49 5556 979 431 Fax: +49 5556 979 190

Job Opening

Astronomer / Astrophysicist
Thüringer Landessternwarte Tautenburg (Germany)

Thüringer Landessternwarte Tautenburg (TLS) is looking for a young astronomer/astrophysicist to be employed as soon as possible. The staff position is initially for three years. Applications from all areas of astronomy are welcome. However, preference will be given to applicants working in fields closely related to the research areas of TLS. These include extrasolar planets (radial velocity and transit searches), star formation, stellar oscillations, gamma ray bursts, and active galaxies. Scientists working in observations or theory will be considered.

The Thüringer Landessternwarte operates a 2-m-telescope in Tautenburg, which can be used in Schmidt-, Cassegrain-, or Coudé-mode. The telescope is equipped with state of the art post-focus instruments for wide-field imaging, low- and high-resolution spectroscopy.

Duties: Successful observational applicants are expected to conduct independent research programs using the 2-m-telescope in Tautenburg, as well as international observatories. We expect such an applicant to partly support the operation of the telescope and its instruments. The successful theory applicant should be able to collaborate with observational astronomers at the institute.

Requirements: Applicants should have a PhD in astronomy, astrophysics, or physics. A demonstrated ability to conduct independent research is highly desirable.

Applications should include a CV, a publication list, a short summary of research interests, a statement of research plans while at TLS, and three letters of reference. Applications will be reviewed starting 1 July and will continue until a suitable candidate is found. Applications can be sent via post to:

Prof. Dr. Artie Hatzes
Thüringer Landessternwarte
Sternwarte 5
D - 07778 Tautenburg
Germany

or via email to artie@tls-tautenburg.de

The contract can start as early as 1 September 2004.
Payment is according to the BAT-O IIa payment scheme of civil servants in Germany.

We especially encourage female applicants to apply for the job.
Handicapped persons of equal qualification will be preferred.
More information about the Thüringer Landessternwarte can be found under http://www.tls-tautenburg.de.

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.***