# COOLNEWS

**A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN**

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## *Stellar Abstracts*

### Theoretical Mass Loss Rates of Cool Main-sequence Stars

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The stellar mass loss rate is important for the rotational evolution of a star and for its interaction with the circumstellar environment. The analysis of astrospheric absorption features enables an empirical determination of mass loss rates of cool stars other than the Sun. We develop a model for the wind properties of cool main-sequence stars, which comprises their wind ram pressures, mass fluxes, and terminal wind velocities. The wind properties are determined through a polytropic magnetised wind model, assuming power laws for the dependence of the thermal and magnetic wind parameters on the stellar rotation rate. We use the empirical data to constrain theoretical wind scenarios, which are characterised by different rates of increase of the wind temperature, wind density, and magnetic field strength. Scenarios based on moderate rates of increase yield wind ram pressures in agreement with most empirical constraints, but cannot account for some moderately rotating targets, whose high apparent mass loss rates are inconsistent with observed coronal X-ray and magnetic properties. For fast magnetic rotators, the magneto-centrifugal driving of the outflow can produce terminal wind velocities far in excess of the surface escape velocity. Disregarding this aspect in the analyses of wind ram pressures leads to overestimations of stellar mass loss rates. The predicted mass loss rates of cool main-sequence stars do not exceed about ten times the solar value. Our results are in contrast with previous investigations, which found a strong increase of the stellar mass loss rates with the coronal X-ray flux. Owing to the weaker dependence, we expect the impact of stellar winds on planetary atmospheres to be less severe and the detectability of magnetospheric radio emission to be lower then previously suggested. Considering the rotational evolution of a $1\,M_\odot$ star, the mass loss rates and the wind ram pressures are highest during the pre-main sequence phase.

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### The Activity of Late-Type Stars: The Sun Among Stars with Cyclic Activity

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The coronal and chromospheric emission of several hundred late-type stars whose activity was recently discovered are analyzed. Based on these new more extensive data we confirm the our previous conclusions for stars of HK project that there exist three groups of objects: active red M dwarfs, G-K stars with cyclic activity, and stars exhibiting high but irregular activity. The X-ray fluxes, EUV - spectra, and X-ray cycles can be used to study the main feature of stellar coronae - the gradual increase in the number of high-temperature ($T \geq 10MK$) regions in the transition from the Sun to cyclically active K dwarfs and more rapidly rotating F and G stars with irregular activity. The level of the X-ray emission is closely related to the spottedness of the stellar surface. The correlation between the chromospheric and coronal emission is weak when the cycles are characterized as Excellent, but becomes strong when the activity is less regular. Unexpectedly, stars whose chromospheric activity is even lower than that of the Sun are fairly numerous. Common and particular features of solar activity among the activity of other stars with activity cycles are discussed. Our analysis suggests a new view of the problem of heating stellar coronae: the coronae of stars with pronounced cycles are probably heated by quasistationary processes in loops, while prolonged nonstationary coronal events are responsible for heating the coronae of F and G stars with high but irregular activity.

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### Flames Observations of the Star Forming Region NGC 6530

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Mechanisms regulating the evolution of pre-main sequence stars can be understood by studying stellar properties such as rotation, disk accretion, internal mixing and binarity. To investigate such properties, we studied a sample of 332 candidate members of the massive and populous star forming region NGC 6530.

We want to select cluster members by using different membership criteria, to study the properties of pre-main sequence stars with or without circumstellar disks.

We use intermediate resolution spectra including the Li I 6707.8 Angstroms line to derive radial and rotational velocities, binarity and to measure the Equivalent Width of the lithium line; these results are combined with X-ray data to study the cluster membership. Optical-IR data and Halpha spectra, these latter available for asubsample of our targets, are used to classify CTTS and WTTS and to compare the properties of stars with and without disks.

We find a total of 237 certain members including 53 binaries. The rotational velocity distributions of stars with IR excesses are statistically different from that of stars without IR excesses, while the fraction of binaries with disks is significantly smaller than that of single stars. Stars with evidence for accretion show circumstellar disks; youth of cluster members is confirmed by the lithium abundance consistent with the initial content.

As indicated by the disk-locking picture, stars with disks have in general rotational velocities lower than stars without disks. Binaries in NGC 6530 seem have undergone a significant disk evolution.

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## Doppler Imaging of Stellar Surface Structure XXIII. The Ellipsoidal K Giant Binary $\zeta$ Andromedae

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We present the first Doppler images of the bright RS CVn-type binary $\zeta$ And. The star is a magnetically active K1 giant with its rotation synchronized to the 17.8-day orbital period. Our revised lithium abundance of $\log n = 1.2$ places $\zeta$ And in the vicinity of Li-rich RGB stars but it is nevertheless a Li-normal chromospherically active binary star. The star seems to undergo its first standard dredge-up dilution. Four consecutive Doppler images were obtained from a continuous 67-night observing run at NSO-McMath in 1996/97. An additional single image was obtained from a continuous 19-night run at KPNO in 1997/98. These unique data allow to compute a small time series of the evolution of the star's surface structure. All line-profile inversions are done with a modified TempMap version that takes into account the non-spherical shape of the star. Representative test reconstructions are performed and demonstrate the code's reliability and robustness. High and low-latitude spot activity was recovered together with an asymmetric polar cap-like feature. The latter dominated the first half of the two-month time series in 1996/97. The second half showed mostly medium-to-high latitude activity and only a fainter polar spot. The coolest areas were restored with a temperature contrast of about 1000±200 K. Some weaker features at equatorial latitudes were also recovered but these could be partially spurious and appear blurred due to imperfect phase coverage. We use our line profiles to reconstruct an average non-sphericity of $R_{\rm pole}/R_{\rm point}$=0.96 which would, if not taken into account, mimic a temperature difference pole-to-equator of ≈220 K, especially at the phases of quadrature. Finally, we apply two different methods for restoring surface differential rotation and found a weak solar-type rotation law with a shear $\Delta\Omega \approx 0.95$ degr/day ($\alpha = \Delta\Omega/\Omega_{\rm eq} = +0.049 \pm 0.003$), i.e. roughly a factor of four weaker at a rotation rate roughly 1.5 times faster than the Sun's.

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## A Non-LTE Study of Neutral and Singly-ionized Calcium in Late-type Stars

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*Aims.* Non-local thermodynamical equilibrium (NLTE) line formation for neutral and singly-ionized calcium is considered through a range of spectral types when the Ca abundance varies from the solar value down to [Ca/H] = −5. We evaluate the influence of departures from LTE on Ca abundance determinations and inspect the possibility of using Ca I / Ca II line-strength ratios as indicators of surface gravity for extremely metal-poor stars.
*Methods.* A comprehensive model atom for Ca I and Ca II is presented. Accurate radiative and electron collisional atomic data are incorporated. The role of inelastic collisions with hydrogen atoms in the statistical equilibrium of Ca I/II is estimated empirically from inspection of their different influences on the Ca I and Ca II lines in selected stars with well determined stellar parameters and high-quality observed spectra.
*Results.* The dependence of NLTE effects on the atmospheric parameters is discussed. Departures from LTE significantly affect the profiles of Ca I lines over the whole range of stellar parameters being considered. However, at [Ca/H] $\geq -2$, NLTE abundance correction of individual lines have a low absolute value due to the different influence of NLTE effects on line wings and the line core. At lower Ca abundances, NLTE leads to systematically depleted total absorption in the line and positive abundance corrections, exceeding +0.5 dex for Ca I $\lambda$4226 at [Ca/H] = −4.9. In contrast, the NLTE effects strengthen the Ca II lines and lead to negative abundance corrections. NLTE corrections are small, $\leq 0.02$ dex, for the Ca II resonance lines, and they grow in absolute value with decreasing Ca abundance

for the IR lines of multiplet 3d - 4p, exceeding 0.4 dex in the metal-poor models with [Fe/H] $\leq -3$. As a test and first application of the Ca I/II model atom, Ca abundances are determined on the basis of plane-parallel LTE model atmospheres for the Sun, Procyon (F IV-V), and seven metal-poor stars, using high S/N and high-resolution spectra at visual and near-IR wavelengths. Lines of Ca I and Ca II give consistent abundances for all objects (except Procyon) when collisions with hydrogen atoms are taken into account. The derived absolute solar Ca abundance (from Ca I and Ca II lines) is $\log \varepsilon_{\mathrm{Ca},\odot} = 6.38 \pm 0.06$. For Procyon, the mean Ca abundance from Ca I lines is markedly subsolar, [Ca/H] $= -0.14 \pm 0.03$. All metal-poor stars within our sample show an overabundance of calcium relative to iron with [Ca/Fe] abundance ratios of 0.26 to 0.46 that are typical of the halo population. The W(Ca I 4226) / W(Ca II 8498) equivalent width ratio is predicted to be sensitive to surface gravity for extremely metal-poor stars, while this is not the case for the ratio involving the Ca II resonance line(s).

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## Magnetospheric Accretion-ejection Processes in the Classical T Tauri Star AA Tau

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From a long time series of high resolution (R=115,000) HARPS spectra and simultaneous broad-band photometry, we report new evidence for magnetospheric accretion as well as ejection processes in the nearly edge-on classical T Tauri star AA Tau.

AA Tau's light curve is modulated with a period of 8.22d. The recurrent luminosity dips are due to the periodic occultation of the central star by the magnetically-warped inner disk edge located at about 9 Rstar. Balmer line profiles exhibit a clear rotational modulation of high-velocity redshifted absorption components with a period of 8.22 days as well, with a maximum strength when the main accretion funnel flow passes through the line of sight. At the same time, the luminosity of the system decreases by about 1 mag, indicative of circumstellar absorption of the stellar photosphere by the magnetically-warped, corotating inner disk edge. The photospheric and HeI radial velocities also exhibit periodic variations, and the veiling is modulated by the appearance of the accretion shock at the bottom of the accretion funnel. Diagnostics of hot winds and their temporal behaviour are also presented.

The peculiar geometry of the young AA Tau system (nearly edge-on) allows us to uniquely probe the acretion-ejection region close to the star. We find that most spectral and photometric diagnostics vary as expected from models of magnetically-channelled accretion in young stars, with a large scale magnetosphere tilted by 20 deg onto the star's spin axis. We also find evidence for time variability of the magnetospheric accretion flow on a timescale of a few rotational periods.

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## Modelling the Components of Binaries in Hyades: The Dependence of the Mixing-length Parameter on Stellar Mass

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We present our findings based on a detailed analysis for the binaries of the Hyades, in which the masses of the components are well known. We fit the models of components of a binary system to the observations so as to give the observed total $V$ and $B-V$ of that system and the observed slope of the main-sequence in the corresponding parts. According to our findings, there is a very definite relationship between the mixing-length parameter and the stellar mass. The fitting formula for this relationship can be given as $\alpha = 9.19(M/M_{\odot} - 0.74)^{0.053} - 6.65$, which is valid for stellar masses greater than $0.77 M_{\odot}$. While no strict information is gathered for the chemical composition of the cluster, as a result of degeneracy in the colour-magnitude diagram, by adopting $Z = 0.033$ and using models for the components of 70 Tau and $\theta^2$ Tau we find the hydrogen abundance to be $X = 0.676$ and the age to be 670 Myr. If we assume that $Z = 0.024$, then $X = 0.718$ and the age is 720 Myr. Our findings concerning the mixing length parameter are valid for both sets of the solution. For both components of the active binary system V818 Tau, the differences between radii of the models with $Z = 0.024$ and the observed radii are only about 4 percent. More generally, the effective temperatures of the models of low mass stars in the binary systems studied are in good agreement with those determined by spectroscopic methods.

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## Models of $\alpha$ Centauri A and B With and Without Seismic Constraints: Time Dependence of the Mixing-length Parameter

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The $\alpha$ Cen binary system is a well-known stellar system with very accurate observational constraints to structure of its component stars. In addition to the classical non-seismic constraints, there are also seismic constraints for the interior models of $\alpha$ Cen A and B. These two types of constraint give very different values for the age of the system. While we obtain 8.9 Gyr for the age of the system from the non-seismic constraints, the seismic constraints imply that the age is about 5.6-5.9 Gyr. There may be observational or theoretical reasons for this discrepancy, which can be found by careful consideration of similar stars. The $\alpha$ Cen binary system, with its solar type components, is also suitable for testing the stellar mass dependence of the mixing-length parameter for convection derived from the binaries of Hyades. The values of the mixing-length parameter for $\alpha$ Cen A and B are 2.10 and 1.90 for the non-seismic constraints. If we prioritize to the seismic constraints, we obtain 1.64 and 1.91 for $\alpha$ Cen A and B, respectively. By taking into account of these two contrasting cases for stellar mass dependence of the mixing-length parameter, we derive two expressions for its time dependence, which are also compatible with the mass dependence of the mixing-length parameter derived from the Hyades stars. For assessment, these expressions should be tested in other stellar systems and clusters.

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## Solar Atmospheric Oscillations and the Chromospheric Magnetic Topology

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*A*ims. We investigate the oscillatory properties of the quiet solar chromosphere in relation to the underlying photosphere, with particular regard to the effects of the magnetic topology.
*M*ethods. We perform Fourier analysis on a sequence of line-of-sight velocities measured simultaneously in a photospheric (Fe I 709.0 nm) and a chromospheric line (Ca II 854.2 nm). The velocities were obtained from full spectroscopic data acquired at high spatial resolution with the Interferometric BIdimensional Spectrometer (IBIS). The field of view encompasses a full supergranular cell, allowing us to discriminate between areas with different magnetic characteristics.
*R*esults. We show that waves with frequency above the acoustic cut-off propagate from the photosphere to upper layers only in restricted areas of the quiet Sun. A large fraction of the quiet chromosphere is in fact occupied by "magnetic shadows", surrounding network regions, that we identify as originating from fibril-like structures observed in the core intensity of the Ca II line. We further show that a large fraction of the chromospheric acoustic power at frequencies below the acoustic cut-off, residing in proximity of the magnetic network elements, directly propagates from the underlying photosphere. This supports recent results arguing that network magnetic elements can channel low-frequency photospheric oscillations into the chromosphere, thus providing a way to input mechanical energy in the upper layers.

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## Variations of the Dipole Magnetic Moment of the Sun during the Solar Activity Cycle

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Observations of the large-scale solar magnetic field (synoptic maps) and measurements of the magnetic field of the Sun as a star (the total magnetic field) are used to determine the dipole magnetic moment and direction of the dipole field for three successive solar cycles. Both the magnetic moment and its vertical and horizontal components vary regularly during the cycle, but never disappear completely. A wavelet analysis of the total magnetic field shows that the amplitude of the 27-day variations of this field is very closely related to the magnetic moment of the horizontal dipole. The reversal of the global dipole field corresponds to a change in the inclination of its axis and occurs in a series of steps lasting one to two years rather than continuously. Before the onset of the reversal, the dipole axis precesses relative to the solar rotational axis, then shifts in a meridianal plane, reaching very low latitudes, where a substantial shift in longitude then begins. These results are discussed in connection with helioseismological data indicating the existence of oscillations with a period of about 1.3 yr and properties of dynamo processes for the case of an inclined rotator.

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## Current Amplification and Magnetic Reconnection at a 3D Null Point. I - Physical Characteristics

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The behaviour of magnetic perturbations of an initially potential three-dimensional equilibrium magnetic null point are investigated. The basic components which constitute a typical disturbance are taken to be rotations and shears, in line with previous work. The spine and fan of the null point (the field lines which asymptotically approach or recede from the null) are subjected to such rotational and shear perturbations, using three-dimensional magnetohydrodynamic simulations. It is found that rotations of the fan plane and about the spine lead to current sheets which are spatially diffuse in at least one direction, and form in the locations of the spine and fan. However, shearing perturbations lead to 3D-localised current sheets focused at the null point itself. In addition, rotations are associated with a growth of current parallel to the spine, driving rotational flows and a type of rotational reconnection. Shears, on the other hand, cause a current through the null which is parallel to the fan plane, and are associated with stagnation-type flows and field line reconnection across both the spine and fan. The importance of the parallel electric field, and its meaning as a reconnection rate, are discussed.

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# *XEST Abstracts*

*Editor's Note:* The abstracts below for the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST) are being cross-listed with the *Star Formation Newsletter.* Additional XEST abstracts can be found in the Sept., Oct, and Nov. 2006 issues of *Coolnews.*

## Spectral Properties of X-ray Bright Variable Sources in the Taurus Molecular Cloud

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*Aims.* We analyze 19 bright variable X-ray sources detected in the *XMM-Newton Extended Survey of the Taurus Molecular Cloud* (XEST), in order to characterize the variations with time of their coronal properties and to derive informations on the X-ray emitting structures.
*Methods.* We performed time-resolved spectroscopy of the EPIC PN and MOS spectra of the XEST sources, using a model with one or two thermal components, and we used the time evolution of the temperatures and emission measures during the decay phase of flares to derive the size of the flaring loops.
*Results.* The light curves of the selected sources show different types of variability: flares, long-lasting decay or rise through the whole observation, slow modulation or complex flare-like variability. Spectral analysis shows typical quiescent plasma temperatures of $\sim 5-10$ MK and $\sim 15-35$ MK; the cool component generally remains constant, while the observed flux changes are due to variations of the hot component. During flares the plasma reaches temperatures up to 100 MK and luminosities up to $\sim 10^{31}$ erg s$^{-1}$. Loop sizes inferred from flare analysis are generally smaller than or comparable to the stellar radius.

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### The XMM-Newton Optical Monitor Survey of the Taurus Molecular Cloud

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The Optical Monitor (OM) on-board XMM-Newton obtained optical/ultraviolet data for the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST), simultaneously with the X-ray detectors. With the XEST OM data, we aim to study the optical and ultraviolet properties of TMC members, and to do correlative studies between the X-ray and OM light curves. In particular, we aim to determine whether accretion plays a significant role in the optical/ultraviolet and X-ray emissions. The Neupert effect in stellar flares is also investigated. Coordinates, average count rates and magnitudes were extracted from OM images, together with light curves with low time resolution (a few kiloseconds). For a few sources, OM FAST mode data were also available, and we extracted OM light curves with high time resolution. The OM data were correlated with Two Micron All Sky Survey (2MASS) data and with the XEST catalogue in the X-rays. The XEST OM catalogue contains 2,148 entries of which 1,893 have 2MASS counterparts. However, only 98 entries have X-ray counterparts, of which 51 of them are known TMC members and 12 additional are TMC candidates. The OM data indicate that accreting stars are statistically brighter in the U band than non-accreting stars after correction for extinction, and have U-band excesses, most likely due to accretion. The OM emission of accreting stars is variable, probably due to accretion spots, but it does not correlate with the X-ray light curve, suggesting that accretion does not contribute significantly to the X-ray emission of most accreting stars. In some cases, flares were detected in both X-ray and OM light curves and followed a Neupert effect pattern, in which the optical/ultraviolet emission precedes the X-ray emission of a flare, whereas the X-ray flux is proportional to the integral of the optical flux.

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### X-ray Emission from T Tauri Stars and the Role of Accretion: Inferences from the XMM-Newton Extended Survey of the Taurus Molecular Cloud

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T Tau stars display different X-ray properties depending on whether they are accreting (classical T Tau stars; CTTS) or not (weak-line T Tau stars; WTTS). X-ray properties may provide insight into the accretion process between disk and stellar surface. We use data from the *XMM-Newton Extended Survey of the Taurus Molecular Cloud* (XEST) to study differences in X-ray properties between CTTS and WTTS. We perform correlation and regression analysis between X-ray parameters and stellar properties. We confirm the existence of a X-ray luminosity ($L_{\rm X}$) vs. mass ($M$) relation, $L_{\rm X} \propto M^{1.69\pm0.11}$, but this relation is a consequence of X-ray saturation and a mass vs. bolometric luminosity ($L_*$) relation for the TTS with an average age of 2.4 Myr. X-ray saturation indicates $L_{\rm X}$ = const$L_*$, although the constant is different for the two subsamples: const = $10^{-3.73\pm0.05}$ for CTTS and const = $10^{-3.39\pm0.06}$ for WTTS. Given a similar $L_*$ distribution of both samples, the X-ray luminosity function also reflects a real X-ray deficiency in CTTS, by a factor of $\approx 2$ compared to WTTS. The average electron temperatures $T_{\rm av}$ are correlated with $L_{\rm X}$ in WTTS but

not in CTTS; CTTS sources are on average hotter than WTTS sources. At best marginal dependencies are found between X-ray properties and mass accretion rates or age. The most fundamental properties are the two saturation laws, indicating suppressed $L_X$ for CTTS. We speculate that some of the accreting material in CTTS is cooling active regions to temperatures that may not significantly emit in the X-ray band, and if they do, high-resolution spectroscopy may be required to identify lines formed in such plasma, while CCD cameras do not detect these components. The similarity of the $L_X$ vs. $T_{av}$ dependencies in WTTS and main-sequence stars as well as their similar X-ray saturation laws suggests similar physical processes for the hot plasma, i.e., heating and radiation of a magnetic corona.

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## X-rays from T Tau: A Test Case for Accreting T Tauri Stars

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*Context.* The generation of X-rays in accreting T Tauri stars (TTS) is thought to be predominantly due to energy dissipation in magnetic fields, but alternative X-ray generation mechanisms have been proposed, such as heating in accretion shocks near the stellar surface, or in shocks forming in jets.
*Aims.* We test models and trends discussed in the previous literature using X-ray data from the classical TTS T Tau.
*Methods.* High-resolution spectroscopy from the Reflection Grating Spectrometers on *XMM-Newton* is used to infer electron densities, element abundances, and the thermal structure of the X-ray source. We also discuss the ultraviolet light curve obtained by the Optical Monitor, and complementary ground-based photometry. A high-resolution image from *Chandra* constrains contributions from the two companions of T Tau N.
*Results.* The X-ray grating spectrum is rich in emission lines, but shows an unusual mixture of features from very hot ($\approx$ 30 MK) and very cool (1–3 MK) plasma, both emitted by similar amounts of emission measure. The cool plasma confirms the picture of a *soft excess* in the form of an enhanced O VII/O VIII Ly$\alpha$ flux ratio, similar to that previously reported for other accreting TTS. Diagnostics from lines formed by this plasma indicate low electron densities ($\lesssim 10^{10}$ cm$^{-3}$). The Ne/Fe abundance ratio is consistent with a trend in pre-main sequence stars in which this ratio depends on spectral type, but not on accretion.
*Conclusions.* On the basis of line density diagnostics, we conclude that the density of the cool "soft-excess" plasma is orders of magnitude below that predicted for an accretion shock, assuming previously determined accretion rates of $(3-6)\times10^{-8}M_\odot\mathrm{yr}^{-1}$. We argue that loading of magnetic field lines with infalling material suppresses the heating process in a fraction of the corona. We thus suggest that the X-ray production of T Tau is influenced by the accretion process although the X-rays may not form in the bulk of the accretion footpoints.

Accepted by A&A, to appear in a special section/issue dedicated to the XMM-Newton Extended Survey of the Taurus Molecular Cloud (XEST).

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*For preprints via ftp or WWW*: http://www.issibern.ch/teams/Taurus/papers.html or

http://www.astro.phys.ethz.ch/papers/guedel/guedel_p_nf.html

# Observations and Models of the Dynamical Evolution of Solar Flares

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Ph.D degree awarded: November 2006

*The full thesis is available here*: http://www.astro.phys.ethz.ch/papers/pgrigis/disspgrigis.pdf

Solar flares and associated Coronal Mass Ejections (CMEs) are the biggest explosions in the solar system, converting huge amounts of magnetic energy into kinetic energy of accelerated particles and heat. The key questions at the core of flare physics research are: how is the energy stored in the solar corona before the flare? What triggers the sudden release of that energy? How are the particles accelerated and heated during the flare? Notwithstanding the strong theoretical and observational progress of the last few decades, this questions still remain open.

Hard X-ray observations of the Sun, such as provided by the Reuven Ramaty High-Energy Solar Spectroscopic Imager (RHESSI), are the best tools to probe the population of flare-accelerated particles, because X-rays are the direct signature of energetic electrons. In this thesis, novel RHESSI hard X-ray observations of solar flares are compared with quantitative predictions from modern theoretical models of stochastic acceleration of electrons. The focus lies on the spectral evolution, which has been discovered in the early days of hard X-ray observations, but, with a few exceptions, neglected by theorists.

The work presented here starts with RHESSI observations of the spectral evolution of the non-thermal component in the hard X-ray spectrum of solar flares. A representative sample of 24 M class impulsive flares is analyzed. They show rapid changes in the spectral hardness during distinct emission spikes. The maximum hardness is reached at peak time, thus the spectral behavior can be classified as soft-hard-soft. A quantitative relation between the normalization of the power-law component and its spectral index is found, holding for single emission spikes, as well as for the whole dataset comprising all events.

The analysis is then expanded, transforming the data from photon space to electron space and comparing the results with predictions from simple available electron acceleration models featuring soft-hard-soft behavior. This simple approach yields plausible best-fit model parameters for about 77% of the 141 events consisting of rise and decay phases of individual hard X-ray spikes. This success suggests that stochastic acceleration is a viable mechanism to explain the observed spectral evolution.

Therefore, a recent stochastic acceleration model, the transit-time damping acceleration scenario, was chosen for further investigation. A mechanism that accounts for particle trapping in the accelerator was added in order to account for changes in the spectral hardness. The model predictions for the spectral evolution were compared with spectral observations of *looptop* hard X-ray sources, delivering a snapshot of the particles still residing in the accelerator. A novel parameter was used for the comparison, the *pivot point* (that is, a common crossing point of the accelerated particle spectra at different times). The model computations show the presence of a pivot point at an energy of 10 keV. This value can be brought in agreement with the observed value of 20 keV by enhanced trapping through an electric potential.

Lastly, some puzzling observations of the motion of hard X-ray sources during an impulsive M class flare are reported. The double sources, interpreted as footpoints of magnetic loops, show continuous motion along an arcade of magnetic loops, contradicting the predictions of the translation invariant 2.5D reconnection models, where motion perpendicular to the arcade is expected. Therefore, the development of more realistic 3D models is needed to account for such behavior.

*Thesis-related Publications*: A&A **458**, 641 (2006); ApJ **625**, L143 (2005); A&A **434**, 1173 (2005); A&A **426**, 1093 (2004); Sol. Phys. **210**, 431 (2002)

*Ph.D. Thesis Abstracts*

# Time-series Analysis of Oscillating Red Giant Stars

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Ph.D dissertation directed by: Timothy R. Bedding

Ph.D degree awarded: November 2006

Stars are the building blocks of the Universe and, as such, are essential to understanding many aspects of astrophysics. Our understanding of cosmology, galaxies and planetary formation all depend on stellar evolution. To understand how stars evolve we need to investigate stars in different evolutionary stages.

The goals of the work presented in this thesis are to investigate the prospects of applying asteroseismic techniques to studying the interiors of red giant stars.

The main achievements and conclusions of this thesis are:

(1) We developed a new technique to measure the mode lifetime of solar-like oscillations. The results point towards a short mode lifetime (roughly 2 days) for the red giant $\xi$ Hya, which contradicts the theoretical value (roughly 20 days) by Houdek & Gough (2002). This discrepancy could be due to the lack of a proper theory for convection in a pulsating environment, which might be important to better understand the driving and damping of solar-like oscillations in evolved stars where the convection is expected to be quite vigorous.

(2) Our simulations of solar-like oscillations in red giant stars showed that large variations are expected in the Fourier spectrum of the oscillations in a given star observed at different epochs. This is an important observation, which should be taken into account when evaluating observations of solar-like oscillations such as mode amplitude, frequency and lifetime.

(3) Simulations of the red giant $\xi$ Hya strongly indicate that no frequencies can be detected unambiguously from the velocity measurements published by Frandsen et al. (2002). This is due to both the non-continuous coverage of the oscillations and the apparently short mode lifetime.

(4) Based on measurements of the mode lifetime and oscillation periods in main-sequence stars and the red giant $\xi$ Hya, there seems to be a steep decline in the quality factor (the period mode-lifetime ratio) towards evolved stars (because the period increases while the mode-lifetime stays roughly the same). This implies that the number of coherent oscillation periods that we can observe will be low for evolved stars, which ultimately limits the precision by which we can determine their frequencies. However, this result needs confirmation from additional observations of either the same star with more continuous data coverage or, preferably, of many red giant stars.

(5) We obtained photometric time series of the open cluster M67 during a multi-site campaign lasting 43 days. The nine telescopes (0.6–2.1 metre) collected in total 560 hours of time series of the cluster. On the best nights the noise was limited by irreducible terms (scintillation and photon noise), and reached down to 0.5 mmag per minute of integration.

(6) Our photometric observations of 20 red giant stars in the open cluster M67 showed excess power in the Fourier spectra consistent with solar-like oscillations. The location of the excess power of three different groups of stars (grouped according to their luminosity) matched with expectations. In three stars, the excess power was more or less in agreement with the expected amplitudes based on $L/M$-scaling. Simulations further supported that a significant part of the excess seen at low frequencies could be of stellar origin for most target stars. It was not possible to obtain

unambiguous detection of a characteristic frequency separation. The signal-to-noise and lack of a clear frequency pattern did not support further extraction of individual peaks. The limitations of this data set was mainly due to the apparent presence of significant non-white noise, which however, could not be quantified or separated clearly from the stellar signal.

*Thesis-related Publications*: SolPhys, 220, 207; A&A 448, 709; MNRAS 373, 1141

*Upcoming Meeting*

# 2007 Gordon Research Conference on Origins of Solar Systems

## 8 - 13 July 2007

## Mt. Holyoke College

## South Hadley, MA

The 2007 Gordon Research Conference on Origins of Solar Systems will be held at Mt. Holyoke College in South Hadley, MA on 8-13 July 2007. This unique interdisciplinary meeting includes astronomers and astrophysicists interested in star and planet formation, planetary scientists and meteoriticists interested in the early history of the Solar System, and plasma and life scientists. This meeting is much broader than most conferences and many fruitful research collaborations have been initiated at Gordon conferences, encouraged by the relaxed pace of the meeting (the Chair has this experience himself).

If you are interested in the subject matter; if you would like to attend a meeting which is not packed solid with talks, but has a limited number of overview talks; if you would enjoy spending extended time reading posters (or would like to have plenty of time for people to look at your poster and even speak with you); and if you might like participating in evening beverage sessions with colleagues from a wide variety of backgrounds, this is the meeting for you.

The Chair and Vice-Chair of the 2007 Origins of Solar Systems conference are Lee Hartmann (Michigan) and Sara Russell (Natural History Museum, London). Please contact us (lhartm@umich.edu, sara.russell@nhm.ac.uk). We expect to announce the invited speakers by the end of November. Information on registering, travel, accomodations, etc. will be available at http://www.grc.org/programs/2007/origins.htm in the very near future.

*Upcoming Meeting*

**First Announcement**

# IAU Symposium No. 243

# Star-Disk Interaction in Young Stars

**21 - 25 May 2007**

**Grenoble, France**

*Rationale*: Disk accretion and jet outflows are intimately associated with the formation of stars and planets. One central issue raised by recent observational studies is the origin of the physical connection between accretion and wind/jet processes. It has become clear that the physical connection takes place within 1 AU of the central star, in a region where the interaction between the star and the inner disk is still poorly understood. The conference is intended to review the observational constraints available on the physical processes thought to be at work at the star-disk interface, to confront the predictions of the latest numerical and analytical MHD models of star-disk-jet systems with observations, and to explore the consequences of these processes for stellar angular momentum evolution and inner disk structure.

*Objectives*: The aim of the conference is to gather astronomers from around the world to critically review the MHD processes which are thought to take place within 1 AU of young stellar objects. It will focus on the structure and variability of the inner magnetized disk, the magnetospheric cavity, and the jet launching region. Understanding the structure and evolution of the star-disk interaction region in young stars is critical to our understanding of the star and planetary system formation process.

*Dedication*: IAU Symposium "Star-disk Interaction in Young Stars" is a tribute to Claude Bertout's pioneering contributions to our understanding of the physics of young stars. In a series of papers published in the late 80's, Bertout and collaborators demonstrated that the UV and IR excesses exhibited by many low mass young stars could be consistently accounted for by assuming the presence of an accretion disk. Disk models aimed at reproducing the spectral energy distribution of young stars additionally suggested truncated inner disks, and the study of photometric variability provided the first evidence for magnetically-channelled accretion onto the star. Nearly 20 years later, IAU Symposium 243 is intended to review our current understanding of the magnetopheric accretion/ejection process in young stars.

*Scientific Organizing Committee*: Silvia Alencar, Immo Appenzeller, Gibor Basri, Jerome Bouvier (chair), Sylvie Cabrit, Suzan Edwards, Moira Jardine, Rony Keppens, Oded Regev, Bo Reipurth, Kazunari Shibata

*Local Organizing Committee*: Silvia Alencar, Immo Appenzeller, Gibor Basri, Jerome Bouvier (chair), Sylvie Cabrit, Suzan Edwards, Moira Jardine, Rony Keppens, Oded Regev, Bo Reipurth, Kazunari Shibata

For a preliminary program and further details, see

**http://www.iaus243.org**

*Upcoming Meeting*

*Second Announcement*

## Structure Formation in the Universe: Galaxies, Stars, Planets

**27 May - 1 June 2007**
**Chamonix, France**

This is the **second annoucement** of the conference *Structure Formation in the Universe*, to be held in Chamonix, France from 27 May through 1 June 2007. The aim of the conference is to bring together researchers working in the fields of planet, star and galaxy formation in order to share their expertise and to address common physical and numerical issues in the understanding of structure formation in astrophysics.

The **registration**, with the possibility to submit a poster presentation, is **now open**, with the hotel reservation. Chamonix is a very touristic location so booking as early as possibly is recommended. All information on the conference website.

*Scientific rationale, final program and list of speakers at:* **http://chamonix2007.ens-lyon.fr/**

*Organizer and contact*: **G. Chabrier (ENS-Lyon; chabrier@ens-lyon.fr)**

## *Announcement: New Book*

The forthcoming book *Methods in Helio- and Asteroseismology* will appear in December with Imperial College Press and may be of interest to some readers/subscribers to Coolnews. See the web page

http://www.icpress.co.uk/physics/p485.html

for further details and the book summary :

This book discusses the methods used in helio- and asteroseismology for the collection, analysis and interpretation of data. It is the first comprehensive discussion of helioseismic and asteroseismic methodology, collecting techniques from over 300 research papers spread out over decades, with a critical discussion and inter-comparison. It enables the reader to follow the path of inference from the collection of the data at the telescope through to the understanding gained in terms of the modeling of solar and stellar physics and stellar evolution. By focusing on how results are obtained, rather than on the results themselves, this book provides the essential background needed to understand this field, which is rapidly advancing due to the availability of modern observing facilities both on the ground and in space. The material is accessible for advanced undergraduates and post-graduates, and provides an essential resource for researchers in the field.

*Submitted by:* Frank P. Pijpers (F.Pijpers@imperial.ac.uk)

# *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.***