COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 92 — October 2003 Editor: Steve Skinner (coolnews@jila.colorado.edu)

TABLE OF CONTENTS

Stellar Abstracts

Rotational Modulation of the Photospheric and Chromospheric Activity in the Young, Single K2-dwarf PW And

J. López-Santiago[1], D. Montes[1], M.J. Fernández-Figueroa[1], L.W. Ramsey[2]

[1]Departamento de Astrofísica, Facultad de Físicas, Universidad Complutense de Madrid, E-28040 Madrid, Spain
[2]The Pennsylvania State University, Department of Astronomy and Astrophysics, 525 Davey Laboratory, University Park, PA 16802, USA

High resolution echelle spectra of PW And (HD 1405) have been taken during eight observing runs from 1999 to 2002. The detailed analysis of the spectra allow us to determine its spectral type (K2V), mean heliocentric radial velocity ($V_{\rm hel} = -11.15$ km s^{-1}) rotational velocity ($v \sin i = 22.6$ km s^{-1}), and equivalent width of the lithium line λ6707.8 Å (EW(Li I) = 273 mÅ). The kinematic (Galactic Velocity (U,V,W)) confirms its membership of the Local Association moving group, in agreement with the age (30 to 80 Myrs) inferred from the color magnitude diagram and the lithium equivalent width. Photospheric activity (presence of cool spots that disturb the profiles of the photospheric lines) has been detected as changes in the the bisectors of the cross correlation function (CCF) resulting of cross-correlate the spectra of PW And with the spectrum of a non active star of similar spectral type. These variations of the CCF bisectors are related to the variations in the measured radial velocities and are modulated with a period similar to the photometric period of the star. At the same time, chromospheric activity has been analyzed, using the spectral subtraction technique and simultaneous spectroscopic observations of the Hα, Hβ, Na I D_1 and D_2, He I D_3, Mg I b triplet, Ca II H&K, and Ca II infrared triplet lines. A flare was observed during the last observing run of 2001, showing an enhancement in the observed chromospheric lines. A less powerful flare was observed on 2002 August 23. The variations of the chromospheric activity indicators seem to be related to the photospheric activity. A correlation between radial velocity, changes in the CCF bisectors and equivalent width of different chromospheric lines is observed with a different behaviour between epochs 1999, 2001 and 2002.

Accepted by A&A

For preprints contact: dmg@astrax.fis.ucm.es

For preprints via ftp or WWW: http://www.ucm.es/info/Astrof/users/dmg/papers/PWAnd_MS3636.pdf

The Weak-line T Tauri Star V410 Tau: I. A Multi-wavelength Study of Variability

B. Stelzer[1], M. Fernández[2], V. M. Costa[3,4], J. F. Gameiro[3,5], K. Grankin[6], A. Henden[7], E. Guenther[8], S. Mohanty[9], E. Flaccomio[1], V. Burwitz[10], R. Jayawardhana[11], P. Predehl[10], R. H. Durisen[12]

[1] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy
[2] Instituto de Astrofísica de Andalucía, CSIC, Camino Bajo de Huétor 24, E-18008 Granada, Spain
[3] Centre for Astrophysics, University of Porto, Rua das Estrelas, 4150 Porto, Portugal
[4] Departamento de Matemática, Instituto Superior de Engenharia do Porto, 4150 Porto, Portugal
[5] Departamento de Matemática Aplicada, Faculdade de Cíencas da Universidade do Porto, 4169 Porto, Portugal
[6] Ulug Beg Astronomical Institute, Astronomicheskaya 33, 700052 Tashkent, Uzbekistan
[7] USRA/USNO Flagstaff Station, P. O. Box 1149, Flagstaff, AZ 86002-1149, USA
[8] Thüringer Landessternwarte, Karl-Schwarzschild-Observatorium, Sternwarte5, D-07778 Tautenburg, Germany
[9] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[10] Max-Planck Institut für extraterrestrische Physik, Postfach 1312, D-85741 Garching, Germany
[11] University of Michigan, 953 Dennison Building, Ann Arbor, MI 48109, USA
[12] Indiana University, 727 E. 3rd Street, Bloomington, IN 47405-7105, USA

We present the results of an intensive coordinated monitoring campaign in the optical and X-ray wavelength ranges of the low-mass, pre-main sequence star V410 Tau carried out with the aim to study the relation between various indicators for magnetic activity that probe emission from different atmospheric layers: optical photometric star spot (rotation) cycle, chromospheric Hα emission, and coronal X-rays.

Two X-ray pointings were carried out with the Chandra satellite simultaneously with the optical observations, and centered near the maximum and minimum levels of the optical lightcurve. A relation of their different count levels to the rotation period of the dominating spot is not confirmed by a third Chandra observation carried out some months later, during another minimum of the 1.87 d cycle. Similarly we find no indications for a correlation of the Hα emission with the spots' rotational phase.

The extraordinary stability of the largest spot is confirmed by long-term photometric and radial velocity measurements. Joining our optical photometry with previous data we provide a new estimate for the dominant periodicity of V410Tau. This updated value removes systematic offsets of the time of minimum observed in data taken over the last decade. Furthermore, the combination of the new data with published measurements taken during the last decade allows us to examine long-term changes in the mean light level of the photometry of V410Tau. A variation on the timescale of 5.4 yr is suggested. Assuming that this behavior is truely cyclic V410Tau is the first pre-main sequence star on which an activity cycle is detected.

Accepted by A&A

For preprints contact: stelzer@astropa.unipa.it

For preprints via ftp or WWW: `http://www.astropa.unipa.it/~stelzer/publications.html`

Differential Rotation on UZ Librae

K. Oláh[1], J. Jurcsik[1] and K.G. Strassmeier[2]

[1] Konkoly Observatory of the Hungarian Academy of Sciences, H-1525 Budapest, Hungary
[2] Astrophysical Institute Potsdam (AIP), An der Sternwarte 16, D-14482 Potsdam, Germany

We analysed a time series of nine consecutive years of high-precision photometry of the spotted RS CVn star UZ Lib by using a discrete Fourier-transform technique and a non-linear least-squares minimization. The main period of 4.77 days due to stellar rotation was resolved into three individual periods separated by -0.2% and $+0.4\%$ around the main period. The stability of the spot pattern over many years, as derived from our contemporaneous Doppler images, allowed us to relate the different periods to co-existing spots at different latitudes, and thus to the direct determination of the strength and the sign of the differential rotation. The main period originates from the equatorial surface regions and is practically the same as the orbital period from independent radial-velocity measurements, suggesting that the stellar equator is tidally locked to the orbital motion. The higher latitudes rotate slightly faster than the equator, suggesting non-solar differential rotation with a parameter of $\alpha = \Delta\Omega/\Omega = -0.0026$, 80 times weaker than on the solar surface, and a lap time of $P_{\mathrm{equator}}/\alpha \approx -1800$ days, i.e. 14 times longer than for the Sun.

Accepted by A&A (in press) (*continued* →)

For preprints contact: olah@konkoly.hu

The Photospheric Abundances of Active Binaries II. Atmospheric Parameters and Abundance Patterns for 6 Single-lined RS CVn Systems

T. Morel[1], G. Micela[1], F. Favata[2], D. Katz[3], and I. Pillitteri[4]

[1] Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Palermo G. S. Vaiana, Piazza del Parlamento 1, I-90134 Palermo, Italy

[2] Astrophysics Division - Research and Science Support Department of ESA, ESTEC, Postbus 299, NL-2200 AG Noordwijk, The Netherlands

[3] Observatoire de Paris, GEPI, Place Jules Janssen, F-92195 Meudon, France

[4] Dipartimento di Scienze Fisiche ed Astronomiche, Università di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy

Photospheric parameters and abundances are presented for a sample of single-lined chromospherically active binaries from a differential LTE analysis of high-resolution spectra. Abundances have been derived for 13 chemical species, including several key elements such as Li, Mg, and Ca. Two methods have been used. The effective temperatures, surface gravities and microturbulent velocities were first derived from a fully self-consistent analysis of the spectra, whereby the temperature is determined from the excitation equilibrium of the Fe I lines. The second approach relies on temperatures derived from the $(B-V)$ colour index. These two methods give broadly consistent results for the stars in our sample, suggesting that the neutral iron lines are formed under conditions close to LTE. We discuss the reliability in the context of chromospherically active stars of various colour indices used as temperature indicators, and conclude that the $(V-R)$ and $(V-I)$ colours are likely to be significantly affected by activity processes. Irrespective of the method used, our results indicate that the X-ray active binaries studied are not as metal poor as previously claimed, but are at most mildly iron-depleted relative to the Sun ($-0.41 <$ [Fe/H] $< +0.11$). A significant overabundance of several chemical species is observed (e.g., the α-synthezised elements). These abundance patterns are discussed in relation to stellar activity.

Accepted by A&A

For preprints contact: morel@astropa.unipa.it

For preprints via ftp or WWW: http://www.astropa.unipa.it/Library/preprint.html

Differential Rotation in Rapidly Rotating F-stars

A. Reiners[1], J.H.M.M. Schmitt[1]

[1] Hamburger Sternwarte, Universität Hamburg, Gojenbergsweg 112, 21029 Hamburg, Germany

We obtained high quality spectra of 135 stars of spectral types F and later and derived "overall" broadening functions in selected wavelength regions utilizing a Least Squares Deconvolution (LSD) procedure. Precision values of the projected rotational velocity $v\,\sin i$ were derived from the first zero of the Fourier transformed profiles and the shapes of the profiles were analyzed for effects of differential rotation. The broadening profiles of 70 stars rotating faster than $v\,\sin i = 45\,\mathrm{km\,s^{-1}}$ show no indications of multiplicity nor of spottedness. In those profiles we used the ratio of the first two zeros of the Fourier transform q_2/q_1 to search for deviations from rigid rotation. In the vast majority the profiles were found to be consistent with rigid rotation. Five stars were found to have flat profiles probably due to cool polar caps, in three stars cuspy profiles were found. Two out of those three cases may be due to extremely rapid rotation seen pole on, only in one case ($v\,\sin i = 52\,\mathrm{km\,s^{-1}}$) solar-like differential rotation is the most plausible explanation for the observed profile. These results indicate that the strength of differential rotation diminishes in stars rotating as rapidly as $v\,\sin i \geq 50\,\mathrm{km\,s^{-1}}$.

Accepted by A&A

For preprints contact: areiners@hs.uni-hamburg.de

For preprints via WWW: http://www.hs.uni-hamburg.de/DE/Ins/Per/Reiners/Publications.htm

Coronal Abundances from High-resolution X-ray Data: The Case of Algol

J.H.M.M. Schmitt[1] and J.-U. Ness[1]

[1] Hamburger Sternwarte, Universität Hamburg, Gojenbergsweg 112, D-21029 Hamburg, Germany

We discuss the determination of elemental abundances from high resolution X-ray data. We emphasize the need for an accurate determination of the underlying temperature structure and advocate the use of a line ratio method which allows us to utilize, first, the strongest lines observed in the X-ray spectra, and second, lines that span a rather wide temperature range. We point out the need to use continuous emission measure distributions and show via example that modeling in terms of individual temperature components yields errors of more than 50 %. We stress the need to derive differential emission measure distributions based on physical assumptions and considerations. We apply our methods to the *Chandra* LETGS spectrum of Algol and show that nitrogen is considerably enhanced compared to cosmic abundances by a factor of 2 while carbon is depleted by at least a factor of 25. Iron, silicon, and magnesium, are all depleted compared to cosmic abundances, while the noble gas neon has the relatively highest abundance.

Accepted by A&A

For preprints contact: jschmitt@hs.uni-hamburg.de

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

Production of Aluminium and the Heavy Magnesium Isotopes in Asymptotic Giant Branch Stars

A. I. Karakas[1] and J. C. Lattanzio[1]

[1] School of Mathematical Sciences, Monash University, Wellington Road, Clayton, VIC 3800, Australia

We investigate the production of aluminium and magnesium in asymptotic giant branch models covering a wide range in mass and composition. We evolve models from the pre-main sequence, through all intermediate stages, to near the end of the thermally-pulsing asymptotic giant branch phase. We then perform detailed nucleosynthesis calculations from which we determine the production of the magnesium and aluminium isotopes as a function of the stellar mass and composition. We present the stellar yields of sodium and the magnesium and aluminium isotopes. We discuss the abundance predictions from the stellar models in reference to abundance anomalies observed in globular cluster stars.

Published in PASA

For preprints contact: akarakas@ap.stmarys.ca

Spatially Resolved X-ray Emission of EQ Pegasi

J. Robrade[1], J.-U. Ness[1], J.H.M.M. Schmitt[1]

[1] Hamburger Sternwarte, Universität Hamburg, Gojenbergsweg 112, D-21029 Hamburg, Germany

We present an analysis of an XMM-Newton observation of the M dwarf binary EQ Pegasi with a special focus on the the spatial structure of the X-ray emission and the analysis of light curves. Making use of data obtained with EPIC (European Photon Imaging Camera) we were for the first time able to spatially resolve the two components in X-rays and to study the light curves of the individual components of the EQ Peg system. During the observation a series of moderate flares was detected, where it was possible to identify the respective flaring component.

Accepted by A&A

For preprints contact: jrobrade@hs.uni-hamburg.de

For preprints via ftp or WWW: http://www.hs.uni-hamburg.de/DE/Ins/Per/Robrade

Flares from Small to Large: X-Ray Spectroscopy of Proxima Centauri with XMM-Newton

Manuel Güdel[1], Marc Audard[2], Fabio Reale[3], Stephen L. Skinner[4] and Jeffrey L. Linsky[5]

[1] Paul Scherrer Institut, Würenlingen and Villigen, CH-5232 Villigen PSI, Switzerland
[2] Columbia Astrophysics Laboratory, Columbia University, 550 West 120th Street, New York, NY 10027, USA
[3] Dipartimento di Scienze Fisiche & Astronomiche, Università di Palermo, 90134 Palermo, Italy
[4] CASA, University of Colorado, Boulder, CO 80309-0389, USA
[5] JILA, University of Colorado, Boulder, CO 80309-0440, USA

We report results from a comprehensive study of the nearby M dwarf Proxima Centauri with the XMM-Newton satellite, using simultaneously its X-ray detectors and the Optical Monitor with its U band filter. We find strongly variable coronal X-ray emission, with flares ranging over a factor of 100 in peak flux. The low-level emission is found to be continuously variable on at least three time scales (a slow decay of several hours, modulation on a time scale of 1 hr, and weak flares with time scales of a few minutes). Several weak flares are characteristically preceded by an optical burst, compatible with predictions from standard solar flare models. We suggest that the U band bursts are proxies for the elusive stellar non-thermal hard X-ray bursts suggested from solar observations. In the course of the observation, a very large X-ray flare started and was observed essentially in its entirety. Its peak luminosity reached 3.9×10^{28} erg s^{-1} [0.15–10 keV], and the total X-ray energy released in the same band is derived to be 1.5×10^{32} ergs. This flare has for the first time allowed to measure significant density variations across several phases of the flare from X-ray spectroscopy of the O VII He-like triplet; we find peak densities reaching up to 4×10^{11} cm^{-3} for plasma of about $1 - 5$ MK. Abundance ratios show little variability in time, with a tendency of elements with a high first ionization potential to be overabundant relative to solar photospheric values. Using Fe XVII lines with different oscillator strengths, we do not find significant effects due to opacity during the flare, indicating that large opacity increases are not the rule even in extreme flares. We model the large flare in terms of an analytic 2-Ribbon flare model and find that the flaring loop system should have large characteristic sizes ($\approx 1R_*$) within the framework of this simplistic model. These results are supported by full hydrodynamic simulations. Comparing the large flare to flares of similar size occurring much more frequently on more active stars, we propose that the X-ray properties of active stars are a consequence of superimposed flares such as the example analyzed in this paper. Since larger flares produce hotter plasma, such a model also explains why, during episodes of low-level emission, more active stars show hotter plasma than less active stars.

Accepted by A&A

For preprints contact: guedel@astro.phys.ethz.ch

Efficiency of Convection and Pre-Main Sequence Lithium Depletion

F. D'Antona[1] and J. Montalbán[2]

[1] INAF, Osservatorio Astronomico di Roma, I–00040 Monteporzio, Italy
[2] Institut d'Astrophysique et de Géophysique, Université de Liège, 4000 Liège, Belgium

We show by detailed model computation how much the Pre-Main Sequence (PMS) Lithium depletion depends on the treatment of over-adiabaticity, by taking advantage of the results of new models by Montalbán et al., which apply different treatments of convection to non-grey PMS models. In order to reproduce both the PMS lithium depletion (inferred from the lithium depletion patterns in young open clusters), and the location of PMS tracks in the HR diagram (inferred from the study of young PMS stars), convection both in the atmosphere and in a good fraction of the stellar envelope must be highly inefficient: e.g., in the Mixing Length Theory approximation, it must have a very low $\alpha = l/H_p$. Unfortunately, the radii of these models are at variance with the solar radius, possibly indicating that there is some additional physical input, generally not taken into account in the stellar models, which affects the efficiency of convection in PMS stars, but probably not in the main sequence stars nor in evolved red giants. We stress the importance of determining precisely masses and lithium abundance in PMS binaries such as the important spectroscopic and eclipsing binary RXJ 0529.4+0041.

Accepted by A&A

For preprints via ftp or WWW: http://www.mporzio.astro.it/ dantona/papers.html

Sunspot Plume Observations in the EUV

J.G. Doyle[1] & M.S. Madjarska[1,2]

[1]Armagh Observatory, Armagh BT61 9DG, N. Ireland
[2]Mullard Space Science Laboratory, University College London, Holmbury St Mary, Dorking, Surrey RH5 6NT

The electron density over a bright sunspot plume region was evaluated using lines within the O V 760 Å multiplet. The plume showed an intensity enhancement factor of ≈ 9 in the O V lines compared to regions outside the sunspot umbra. Internal agreement between the various ratios is excellent which would suggest that the O V lines do not suffer from blending problems. The derived mean electron densities for the sunspot plume is $\log N_e/cm^{-3} \approx 9.9$ compared to $\log N_e/cm^{-3} \approx$ *10.20*–10.45 in the surrounding area. The derived gas pressure in the plume compared to that outside leads weight to the suggestion that it is plasma flowing from outside the spot into the umbra at transition region temperatures that is the main cause of the down-flows. The plume non-thermal velocities are 5 to 10 km s^{-1} smaller than those measured in regions external to the spot, suggesting significantly less turbulence within the umbra.

Accepted by A&A

For preprints contact: jgd@star.arm.ac.uk

For preprints via WWW: http://star.arm.ac.uk/preprints/

Coronal Oscillations Above Sunspots?

J.G. Doyle[1] & M.S. Madjarska[1,2]

[1]Armagh Observatory, Armagh BT61 9DG, N. Ireland
[2]Mullard Space Science Laboratory, University College London, Holmbury St Mary, Dorking, Surrey RH5 6NT

Observational data clearly indicate the presence of 3 min oscillations in sunspots in spectral lines covering a vast temperature range from the low chromosphere to those lines normally associated with coronal temperatures. We show that after folding in the sunspot plume emission measure distribution, the contribution functions for lines normally formed just below 1×10^6 K are shifted to lower temperatures. For example, the Fe IX 171 Å line is shifted to 6×10^5 K for a Maxwellian distribution and to less than 5×10^5 K with a non-Maxwellian distribution. Other lines such as Mg IX 368 Å will also be effected. This then questions some previous work regarding the suggested detection of 3 min oscillations in the corona above sunspots.

Accepted by Solar Physics

For preprints contact: jgd@star.arm.ac.uk

For preprints via WWW: http://star.arm.ac.uk/preprints/

Simultaneous Observations of Solar Transition Region Blinkers and Explosive Events by SUMER, CDS and BBSO: Are Blinkers, Explosive Events and Spicules the Same Phenomenon?

M.S. Madjarska[1] & J.G. Doyle[1]

[1]Armagh Observatory, Armagh BT61 9DG, N. Ireland

The SoHO discovery of the new 'blinker' phenomena focused our study on the search of its relation to already known phenomena such as explosive events and spicules. The study was performed using a specially planned joint observing program involving the Coronal Diagnostic Spectrometer (CDS), Solar Ultraviolet Measurements of Emitted Radiation spectrograph (SUMER) and Big Bear Solar Observatory (BBSO) magnetograph. Within each blinker, the SUMER data reveal the presence of small-scale ($3'' - 5''$), short-lived (2-3 min) bright features not seen in the CDS data which has sometimes being interpreted as oscillations in SUMER data. With this data we have clearly identified UV explosive events in CDS data. The explosive events show a size close to the small-scale brightenings forming the blinker core. However, they appear in the SUMER data with their typical strong blue and red wings while the blinker shows at best only a small increase in the emission of the blue and red wings and in most instances the typical transition region red-shift in the center of the line. In all cases the explosive events cover one pixel in CDS corresponding to a size

of 4" × 4" − 6". All identified explosive events were located at the border of the bright network i.e. the blinker, in the network or even in the internetwork. From this data, we believe that blinkers and explosive events are two separate phenomena not directly related or triggering each other. In this study, the Doppler shift was derived in a blinker phenomenon for the first time. It ranges from −5 to 25 km s^{-1} and is predominantly red-shifted. The observed magnetic flux increase during the blinker phenomena seems to play a crucial role in the development of this event. We suggest that 'blinkers' maybe the on-disk signature of spicules.

Accepted by A&A

For preprints contact: jgd@star.arm.ac.uk

For preprints via WWW: http://star.arm.ac.uk/preprints/

An EUV Bright Point as Seen by SUMER, CDS, MDI and EIT On-board SoHO

M.S. Madjarska[1], J.G. Doyle[1], L. Teriaca[2], & D. Banerjee[3]

[1]Armagh Observatory, Armagh BT61 9DG, N. Ireland

[2]Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy

[3]Centre for Plasma Astrophysics, Katholieke Universiteit Leuven, Celestijnenlaan 200B, 3001 Leuven, Belgium

This paper presents the formation, evolution and decay of a coronal bright point via a spectroscopic analysis of its transition region counterpart and the evolution of the underlying magnetic bipole during 3 days of almost continuous observations. The data were obtained with various instruments on-board SoHO, including the SUMER spectrograph in the transition region line S VI 933.40 Å, CDS in the He I 584.33, O V 629.73 and Mg IX 368.06 Å lines, plus MDI and EIT. The existence of the coronal feature is strongly correlated with the evolution of the underlying bipolar region. The lifetime of the bright point from the moment when it was first visible in the EIT images until its complete disappearance was ∼ 18 hrs. Furthermore, the bright point only became visible at coronal temperatures when the two converging opposite magnetic polarities were ∼ 7 000 km apart. As far as the temporal coverage of the data permits, we found that the bright point disappeared at coronal temperatures after a full cancellation of one of the magnetic polarities. The spectroscopic analysis reveals the presence of small-scale (∼ 6") transient brightenings within the bright point with a periodicity of ∼ 6 min. The Doppler shift in the bright point was found to be in the range of −10 to 10 km s^{-1} although it is dominated by a red-shifted emission which is associated with regions characterized by stronger 'quiet' Sun photospheric magnetic flux. Small-scale brightenings within the bright point show velocity variations in the range 3 − 6 km s^{-1}. In general the bright point has a radiance ∼ 4 times higher than that of the network. No relation was found between the bright point and the UV explosive event phenomena.

Accepted by A&A

For preprints contact: jgd@star.arm.ac.uk

For preprints via WWW: http://star.arm.ac.uk/preprints/

The Energy Equation in the Lower Solar Convection Zone

Bernard R. Durney [1]

[1] Dept. of Physics, University of Arizona, Tucson, AZ 85721, and National Solar Observatory, Tucson, AZ 85725

As a consequence of the Taylor-Proudman balance, a balance between the pressure, Coriolis and buoyancy forces in the radial and latitudinal momentum equations (that is expected to be amply satisfied in the lower solar convection zone, SCZ), the superadiabatic gradient is determined by the rotation law and by an unspecified function of r, say, $S'_\Omega(r)$, where r is the radial coordinate. If the rotation law and $S'_\Omega(r)$ are known, then the solution of the energy equation, performed in this paper in the framework of the MLΩ formalism, leads to a knowledge of the Reynolds stresses, convective fluxes, and meridional motions. The ML$\Omega-$ formalism is an extension of the mixing length theory to rotating convection zones, and the calculations also involve the azimuthal momentum equation, from which an expression for the meridional motions in terms of the Reynolds stresses can be derived.

The meridional motions are expanded as $U_r(r,\theta) = P_2(\cos\theta)\psi_2(r)/r^2\rho + P_4(\cos\theta)\psi_4(r)/r^2\rho + ...$, and a corresponding equation for $U_\theta(r,\theta)$. Here θ is the polar angle, ρ is the density, and $P_2(\cos\theta)$, $P_4(\cos\theta)$ are Legendre polynomials. A good approximation to the meridional motion is obtained by setting $\psi_4(r) = -H\psi_2(r)$ with $H \approx -1.6$, a constant. The value of $\psi_2(r)$ is negative, i.e., the P_2-flow rises at the equator and sinks at the poles. For the value of H obtained

in the numerical calculations, the meridional motions have a narrow countercell at the poles, and the convective flux has a relative maximum at the poles, a minimum at mid latitudes and a larger maximum at the equator. Both results are in agreement with the observations.

Accepted by Solar Physics

For preprints contact: durney@physics.arizona.edu, durney@noao.edu

Why Solar Magnetic Flux Concentrations are Bright in Molecular Bands

M. Schüssler[1], S. Shelyag[1], S.V. Berdyugina[2], A. Vögler[1], and S. K. Solanki[1]

[1] Max-Planck-Institut für Aeronomie, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany

[2] Institut für Astronomie, ETH Zentrum, 8092 Zürich, Switzerland

Using realistic ab-initio simulations of radiative magneto-convection, we show that the bright structures in images taken in the 'G band', a spectral band dominated by lines of the CH molecule, precisely outline small-scale concentrations of strong magnetic field on the visible solar surface. The brightening is caused by a depletion of CH molecules in the hot and tenuous magnetic structures, thus confirming the model of radiatively heated magnetic flux concentrations. These results provide a firm basis for observational studies of the evolution and dynamics of the small-scale solar magnetic field derived through 'proxy magnetometry' with G-band images.

Accepted by ApJL

For preprints contact: schuessler@linmpi.mpg.de

For preprints via ftp or WWW: http://www.astro.phys.ethz.ch/papers/berdyugina/berdyugina_p_nf.html

Magnetic Helicity Transport in Corona and Filament Eruptions

P. Romano [1], L. Contarino [1] and F. Zuccarello [1]

[1] Dipartimento di Fisica e Astronomia, Univ. of Catania, Via S. Sofia 78, 95125, Catania, Italy

Using a 28 hours time series of line-of-sight magnetograms, taken by the Michelson Doppler Imager (MDI), we determined the magnetic flux variations and the rate of magnetic helicity transport at the footpoints of a filament in active region NOAA 8375. The filament was characterized by a positive helicity change due to shearing motions in both footpoints and showed several partial eruptions during the observing time. In particular, we considered 4 events registered in the Hα daily reports of Solar Geophysical Data. We found a strong temporal correlation between filament eruptions and helicity transport from the photospheric magnetic structures at the filament footpoints into the corona: in at least one footpoint, all of the events were preceded by an evident increase and followed by a small decrease of the emerging magnetic flux and of the magnetic helicity change due to shearing motions. We compared these two mechanisms of helicity transport and found that the preminent role to drive filament instab ility is played by emergence of new magnetic flux from the convection zone.

Accepted by Solar Physics

For preprints contact: prom@ct.astro.it

Low-Mass & Substellar Abstracts

On the Universal Outcome of Star-formation: Is There a Link Between Stars and Brown-dwarfs?

Pavel Kroupa[1,2], Jerome Bouvier[1], Gaspard Duchêne[3], Estelle Moraux[1]

[1] Laboratoire d'Astrophysique de l'Observatoire de Grenoble, BP 53, F-38041 Grenoble Cedex 9, France
[2] Institut für Theoretische Physik und Astrophysik der Universität Kiel, D-24098 Kiel, Germany
[3] Department of Physics and Astronomy, 405 Hilgard Avenue, UCLA, Los Angeles, CA 90095-1562, USA

Given the current consensus that stars form from pre-stellar cloud cores that fragment into small$-N$ groups which decay within a few 10^4 yr, and taking the observed properties of about 1 Myr old stars in the Taurus-Auriga (TA) star-forming region as empirical constraints, we suggest a model that describes the multiplicity properties of the disintegrated groups. This model concisely describes the outcome of star formation in terms of dynamically unevolved binary properties. Two variants of the model are tested against data on very young stars in Taurus-Auriga (TA) and the Orion Nebula cluster (ONC) as well as the older Pleiades and the Galactic-field populations. The *standard model* (SM) assumes that cloud-core fragmentation only produces stellar systems, while the *standard model with brown dwarfs* (SMwBDs) assumes that cloud-core fragmentation proceeds down to sub-stellar mass cores. Brown dwarfs (BDs) enter the SM by being a separate, dynamically unimportant population. The models produce a very high initial binary proportion among stars (SM), and stars and BDs (SMwBDs), and both reproduce the measured initial mass function (IMF) in TA, the ONC and the Pleiades as well as the Galactic field. Concentrating on the SMwBDs, it is shown that the Briceno et al. result that TA appears to have produced significantly fewer BDs per star than the ONC is reproduced almost exactly without calling for a different IMF. The reason is that star–BD and BD–BD binaries are disrupted in the dense ONC. The model, however, fails to reproduce the observed star–star binary period distribution in TA, because it contains too many star–BD pairs. Also, the SMwBDs leads to too many wide star–BD and BD–BD systems. This is a problem if most stars form in clusters because Galactic-field very-low-mass-star and BD binaries have a low binary fraction and do not contain wide systems. The SM, on the other hand, finds excellent agreement with the observed mass-ratio and period distribution among TA and Galactic-field stellar binaries, as well as the observed stellar period distribution in the ONC and the Pleiades. The conclusion of this work is therefore that the SM describes the initial, dynamically unevolved stellar population very well indeed for a large range of star-forming conditions, suggesting (1) a remarkable invariance of the star-formation products, and (2) that BDs (and some very-low-mass stars) need to be added as a separate population with its own kinematical and binary properties. This separate population may vary with star-forming conditions.

Accepted by MNRAS

For preprints contact: pavel@astrophysik.uni-kiel.de

For preprints via ftp or WWW: http://xxx.lanl.gov/abs/astro-ph/0307229

On the Origin of Brown Dwarfs and Free-floating Planetary Mass Objects

Pavel Kroupa[1,2], Jerome Bouvier[1]

[1] Laboratoire d'Astrophysique de l'Observatoire de Grenoble, BP 53, F-38041 Grenoble Cedex 9, France
[2] Institut für Theoretische Physik und Astrophysik der Universität Kiel, D-24098 Kiel, Germany

Briceno et al. report a significantly smaller number of brown dwarfs (BDs) per star in the Taurus-Auriga (TA) pre-main sequence stellar groups than in the central region of the Orion Nebula cluster (ONC). Also, BDs have binary properties that are not compatible with a star-like formation history. It is shown here that these results can be understood if BDs are produced as ejected embryos with a dispersion of ejection velocities of about 2 km/s and if the number of ejected embryos is about one per four stars born in TA and ONC. The Briceno et al. observation is thus compatible with a universal BD production mechanism and a universal IMF, but the required number of BDs per star is much too small to account for the one BD per star deduced to be present in the Galactic field. There are two other mechanisms for producing BDs and free-floating planetary-mass objects (FFLOPs), namely the removal of accretion envelopes from low-mass proto-stars through photo-evaporation through nearby massive stars, and hyperbolic collisions between proto-stars in dense clusters. The third BD flavour, the collisional BDs, can be neglected in the ONC. It is shown that the observed IMF with a flattening near $0.5\,M_\odot$ can be re-produced via photo-evaporation of proto-stars if they are distributed according to a featureless Salpeter MF above the sub-stellar mass limit, and that the photo-evaporated BDs should have a smaller velocity dispersion than the stars. The number of photo-evaporated BDs per star should increase with cluster mass, peaking in globular clusters that would have contained many stars as massive as $150\,M_\odot$. The required number of embryo-ejected BDs in TA and the ONC can be as low as 6 ejected BDs per 100 stars if the central ONC contains 0.23 photo-evaporated BDs per star. Alternatively, if the assumption is discarded that embryo ejection must operate equally in all environments, then it can be argued that TA produced about one ejected BD per star leading to consistency with the Galactic-field observations. The dispersion of ejection velocities would be about 3 km/s. In the central ONC the number of ejected BDs per star would then be at most 0.37, or less if photo-evaporated BDs contribute. This non-universal scenario would thus imply that the Galactic-field BD population may mostly stem from TA-like star formation or modest clusters, the ONC not being able to contribute more than about 0.25 ± 0.04 BDs per star.

Accepted by MNRAS

For preprints contact: pavel@astrophysik.uni-kiel.de

For preprints via ftp or WWW: http://xxx.lanl.gov/abs/astro-ph/0309645

The Effect of the Electron Donor H_3^+ on the Pre-main and Main Sequence Evolution of Low Mass Zero Metallicity Stars

G. J. Harris[1], A. E. Lynas-Gray[1,2], S. Miller[1] and J. Tennyson[1]

[1] Department of Physics and Astronomy, University College London, London, WC1E 6BT, UK

[2] Department of Physics, University of Oxford, Keble Road, Oxford OX1 3RH, UK

H_3^+ has been shown (Lenzuni et al. 1991, ApJS, 76, 759) to be the dominant positive ion, in a zero metallicity gas at low temperature and intermediate to high density. It therefore affects both the number of free electrons and the opacity of the gas. The most recent H_3^+ partition function (Neale and Tennyson, 1995, ApJ, 454, L169) is an order of magnitude larger at 4000 K than all previous partition functions, implying that H_3^+ is a more important electron donor than previously thought.

Here we present new Rosseland mean opacities for a hydrogen-helium gas of $1000 \leq \mathrm{T(K)} \leq 9000$ and $-14 \leq \log_{10}(\rho\ [\mathrm{g\ cm^{-3}}]) \leq -2$. In the calculation of these opacities we have made use of the latest collision induced absorption data as well as the most recent H_3^+ partition function and line opacity data. It is shown that these updated and new sources of opacity give rise to a Rosseland mean opacity for a hydrogen-helium gas which is in general greater than that calculated in earlier works.

The new opacity data are then used to model the evolution of low mass 0.15-0.8 $M_\odot$ zero metallicity stars, from pre-Main Sequence collapse to Main Sequence turn-off. To investigate the effect of H_3^+ on the evolution of low mass zero metallicity stars, we repeat our calculations neglecting H_3^+ as a source of electrons and line opacity. We find that H_3^+ can have an effect on the structure and evolution of stars of mass $\sim$0.5 $M_\odot$ or less. A gray atmosphere is used for the calculation, which is sufficient to demonstrate that H_3^+ affects the evolution of very low mass stars to a greater degree than previously believed.

Accepted by ApJ

For preprints contact: j.tennyson@ucl.ac.uk

For preprints via ftp or WWW: http://arxiv.org/abs/astro-ph/0309487

Upcoming Meeting

First Announcement

The First International Symposium on SPACE CLIMATE: Direct and Indirect Observations of Long-Term Solar Activity

20 - 23 June 2004

Oulu, Finland

Dear Colleagues:

The First International Symposium on SPACE CLIMATE: Direct and Indirect Observations of Long-Term Solar Activity will be held in Oulu, Finland, on June 20-23, 2004 (at the Summer Solstice, only 200 km from the Artic Circle).

The Symposium aims to cover a wide range of topics nowadays covered under the apt nickname of Space Climate, i.e., the long-term change in the Sun, heliosphere and near-Earth space. The topics of the Symposium include, e.g.,

Long-term cyclicities in solar activity; Extremes in solar activity: Great minima and active times; Problems in solar cycle evolution (e.g. lost cycle in Dalton minimum?); Long-term stellar magnetic cycles; Long-term behaviour of solar rotation; Long-term helioseismic observations; Different modes of stellar dynamos; Long-term changes in the heliosphere; Cosmogenic isotopes as long-term solar proxies; Long-term cosmic ray variations; Long-term geomagnetic and auroral activity; Long-term changes in spatial distribution of solar activity: N-S asymmetry, active longitudes, butterfly diagram etc.

Scientific Organizing Committee (partly to be confirmed): J. Beer, E. Cliver, A. Ferriz-Mas, D. Hoyt, V. Makarov, R. Marsden, H. Moraal, K. Mursula, H. Nevanlinna, J.-P. Rozelot, M. Shea, S. Solanki, I. Tuominen, I. Usoskin

The Symposium aims to discuss the above and related topics in an inspiring and informal atmosphere of the Northern Finland during the time of continuous lightness. The program will consist of a number of invited talks, short presentations by everyone interested with time reserved for discussions. We aim to have a selection of contributions to be published in a refereed forum.

Further information can be found at the web-site: http://cosmicrays.oulu.fi/SpaceClimate1/ This web page will be updated with more details as the Symposium draws closer. You will also find information here on the venue of the meeting, the weather and sights that you can expect.

We also note that this Symposium is planned to be just after the IAU Symposium "Multi-Wavelength Investigations of Solar Activity" in St. Petersburg, Russia, in 14-19 June 2004. This will significantly reduce the total travel costs of those who would like to go to both meetings. They can, e.g, fly to Helsinki, and take the trips from there very conveniently first to StPb and then to Oulu either by plane, train, bus or even boat (to StPb only).

You can send your message of interest and/or potential participation to SpaceClimate1@oulu.fi or use web registration (after it will be available in a near future), or contact one of us directly.

Yours sincerely

Kalevi Mursula (kalevi.mursula@oulu.fi)
Ilya Usoskin (ilya.usoskin@oulu.fi)

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.***