COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

On the Evolutionary Status of the AB Dor + Rst 137B System

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We present CCD measurements of the $V(RI)_C$ colours of Rossiter 137B, the low-mass proper-motion companion to the rapidly rotating southern K0 dwarf star AB Doradus. We find that, contrary to earlier reports, there appears to be no discrepancy between the evolutionary states of the two stars, whose relative and absolute magnitudes and colours can be reconciled with isochrones with ages of order 30 Myr. A re-examination of the $V-R$ and $V-I$ colours of AB Dor leads to a revised angular diameter of 0.69 ± 0.06 milliseconds of arc, somewhat greater than earlier estimates. Combined with recent VLBI parallax measurements, this gives AB Dor a radius close to solar. The observed rotation period and $v \sin i$ then yield an axial inclination that is most probably close to 60°, consistent with the optimum value suggested by Doppler imaging, but could be as high as 90°.

Accepted by The Observatory

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The Angular Momentum Evolution of Low-mass Stars

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We present a model for the evolution of surface rotation of stars in the mass range from 0.5 to $1.1 M_\odot$, from their first appearance in the HR diagram as T Tauri stars up to the age of the Sun. The model is based on 3 assumptions: i) nearly solid-body rotation, ii) pre-main sequence disk locking, iii) wind braking. The initial conditions and the calibration of the braking law are completely determined from observations. The model includes only 2 adjustable parameters: the distribution of disk lifetimes in the pre-main sequence and the velocity at which saturation of the angular momentum losses due to the stellar wind occurs.

We review all the observational results, including the most recent ones, that can be used to constrain the models, as well as theoretical work that puts limits onto the parameter space. We show that the currently available distributions of $v\sin i$ for PMS, ZAMS and MS stars can be reasonably well reproduced by the model assuming solid-body rotation for stars in the mass-range from 0.5 to 1.1$M_\odot$. We deduce a median lifetime of 3 Myr for circumstellar accretion disks around pre-main sequence stars. By an age of 20 Myr, only 10% of the stars are still surrounded by disks. Stars with long disk lifetimes and low initial rotational velocities account for the large fraction of slow rotators ($v\sin i \leq 20$ km.s^{-1}) observed in young clusters. On the opposite, stars with short-lived disk reach the ZAMS with velocities up to 200 km.s^{-1} over the whole mass range investigated here.

In agreement with other models, we find that a mass-dependent saturation velocity for the angular momentum losses is required to account for the longer spin down timescale of lower mass stars on the zero-age main sequence. We argue that this assumption provides an alternative to the hypothesis of radiative core–convective envelope decoupling, which has been used in other models. Both the rapid spin down of fast rotators on the ZAMS and its mass-dependency are accounted for in the present solid-body rotation models. In particular, we show that the model predicts a distribution of rotational periods at the age of the Hyades for 0.5-1.1$M_\odot$ stars that is in close agreement with the observations. We conclude that the observed evolution of *moderate and fast rotators* on the early main sequence requires physical processes that lead to the redistribution of angular momentum in stellar interiors on a timescale much shorter than evolutionary timescales, such as dynamical rotational instabilities, gravity waves or MHD torques. The evolution of *slow rotators* ($v\sin i \leq 10$ km.s^{-1}), however, remains uncertain due to the currently uncomplete $v\sin i$ distribution. Precise $v\sin i$ measurements for slow rotators in young clusters, rather than upper limits, are required.

Accepted by A&A

For preprints contact: http://www.cfht.hawaii.edu/~bouvier/bouvier.html

Editor's Note: The above cross-disciplinary abstract has also been submitted to the *Star Formation Newsletter*.

Long-term Monitoring of Active Stars. VII. UBV(RI)$_c$ Photometry Collected in March 1991

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High-precision UBV(RI)$_c$ photometry of 19 active stars, collected at the European Southern Observatory over the 15-31 March 1991 interval, is presented. Significant evolution of the light curves, period variations and, in most cases, evidence for long-term variability of the global degree of spottedness are found. Most of the spectral classifications are discussed.
The stars observed are: HD 32918 = YY Men, HD 36705 = AB Dor, HD 37847 = TW Lep, HD 39917 = SZ Pic, HD 61245 = V 344 Pup, HD 81410 = IL Hya, HD 82558 = LQ Hya, HD 86005, HD 98712 = SZ Crt, HD 101309 = V 829 Cen, HD 102077 = V 838 Cen, HD 106225 = HU Vir, HD 119285 = V 851 Cen, HD 127535 = V 841 Cen, HD 136905 = GX Lib, HD 139084 = V 343 Nor, HD 155555 = V 824 Ara, HD 174429 = PZ Tel, HD 197481 = AU Mic.
A flare event was detected for the star HD 127535 = V 841 Cen.

Accepted by A&AS

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Long-term Photometric Flares Patrol (1967-1977) on EV Lac: A Clear Evidence of a Longitude Concentrated Flaring Activity in 1970

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We report on a large sample of homogeneous photoelectric data obtained by monitoring the red dwarf flare star EV Lac. The data were collected in 10 years (1967-77) at Catania Astrophysical Observatory on Mt. Etna and consist of 212, 170, and 128 flares detected in the U, B and V band during total monitoring times of 903, 1013, and 864 hours, respectively.

The peak luminosity, the total energy emitted, the rise and decay times were measured for each flare. A statistical analysis of this data sample is presented.

A well defined phase modulation of the normalized flare occurrence rate in 1970 cleary suggests that, at that time, on EV Lac flaring activity was concentrated at a preferred longitude.

Accepted by A&A

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Probing the LHS Catalog. I. New Nearby Stars and the Coolest Subdwarf

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We present moderate resolution spectroscopy of 112 cool dwarf stars to supplement the observations we have already presented in the Palomar/MSU Nearby-Star Spectroscopic Survey. The sample consists of 72 suspected nearby stars added to the *The Preliminary Third Catalogue of Nearby Stars* since 1991 as well as 40 faint red stars selected from the LHS catalog. LHS 1826 is more metal-poor and cooler than the coolest previously known extreme subdwarf, LHS 1742a. LHS 2195 is a very late M-dwarf of type M8V, probably at a distance of ten parsecs. LHS 1937 is an M7V star at $\sim$ 20 parsecs. Three other previously unobserved LHS stars have estimated distances that place them within 25 parsecs.

Accepted by PASP (to appear August 1997)

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Brown Dwarf Candidates in Praesepe

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We present a deep R, I and Z band photometric survey of the open cluster Praesepe. Twenty six new photometric candidates have been found with I $>$ 17.8, extending Praesepe's main sequence down to I=21.5. Nineteen of the new members are Brown Dwarf candidates, and 2 could be binary Brown Dwarfs. Praesepe's mass function is derived, and found to be rising into the Brown Dwarf range with $\alpha \geq 1.5$.

Accepted by MNRAS (vol. 287)

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Silicon and Sulfur Chemistry in the Inner Wind of IRC+10216

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We present a dynamical and chemical model of the inner wind of the carbon-rich, AGB star IRC+10216. We include the effect of pulsation-driven shocks on the gas envelope close to the stellar photosphere and construct an extended chemical model that includes in particular the chemistry of hydrocarbon species and silicon and sulphur-bearing molecules. The derived theoretical abundances for many molecules are in excellent agreement with values obtained from observations of infrared ro-vibrational molecular lines. We confirm the "parent" character of certain chemical species and show that the inner wind of IRC+10216, and more generally of evolved AGB stars, is an active dynamical and chemical region where molecules are formed and processed.

Submitted to A&A

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On the Widespread Weak-Line T-Tauri Population Detected in the ROSAT All-Sky Survey

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We discuss the apparent widespread presence of Weak-Line T-Tauri stars (WTTS) among stellar coronal sources detected in the ROSAT All-Sky Survey (RASS), and their relative number with respect to young main-sequence stars in the same samples. The approach taken in most of the current literature for identifying and classifying WTT stars among RASS X-ray sources is based on the usage of low-resolution optical spectra only and on simple, mass-independent thresholds on the equivalent width of the Li I 6707.8 Å doublet. We show that this approach is likely to lead to putative WTTS samples which contain a large number of normal, young main-sequence stars masquerading as WTTS sources. Young main-sequence stars are known to be the dominant contributor in stellar X-ray selected samples at the limiting flux levels of the RASS, yet they appear to be very rare in the RASS samples discussed here. We argue that many of the putative WTTS sources are actually mis-classified young main-sequence stars, and that thus there is likely not a true "WTTS question" in the RASS samples.

Accepted by A&A

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Editor's Note: The above cross-disciplinary abstract has also been submitted to the *Star Formation Newsletter*.

EUV Spectroscopy of Cool Stars. III. Interpretation of EUVE Spectra in Terms of Quasi-static Loops

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We discuss the limitations of coronal spectroscopy to derive physical parameters of stellar magnetic loops. We distinguish between the intrinsic non-uniqueness of emitted spectra for models of quasi-static coronal loops, and the supplemental ambiguity introduced by both instrumental effects and spectral line formation. We demonstrate that the spectrum emitted by loops with constant cross-sections is the same for a large range of values of the conductive flux at the base when the apex temperature is fixed. Because it is impossible to estimate the conductive flux at the base from observations, it is also impossible to determine the volume heating rate and the loop length uniquely. For geometrically expanding (tapered) loops, the emitted spectrum depends on the expansion and on the conductive flux at the base, and there is a trade off between them without significant changes in the spectrum. We show that loop length and heating rate can only be derived if the density is known, but that even then a large intrinsic uncertainty remains for these loop parameters. We conclude that there is no unambiguous relationship between loop parameters and emitted spectra: modeling the spectra as the sum of spectra from discrete loops cannot result in a unique determination of coronal structure.

Based on spectra observed with the Extreme UltraViolet Explorer (*EUVE*) we find that quasi-static loop models allow adequate modeling of stellar coronal spectra. We show that coronal loops on active cool stars must expand with height. The minimum required areal expansion between base and apex is not very large, lying between 2 and 5. For three stars (α Cen, Capella and ξ UMa) the observations suggest the presence of two distinct, dominant loop populations, while for χ^1 Ori a single population, characterized by a single apex temperature, suffices. The high electron densities ($10^{12} - 10^{13}$ cm^{-3}) for coronal components on Capella and ξ Uma require abnormally large heating rates. It is likely that these high densities are related to a multitude of small volumes that are temporarily excited.

Accepted by A&A

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Zeeman-Doppler Imaging of Active Stars V. Sensitivity of Maximum Entropy Magnetic Maps to Field Orientation

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In 1989, Semel proposed a new technique (dubbed Zeeman-Doppler imaging or ZDI) for measuring and mapping magnetic fields at the surface of cool active stars from sets of rotationally modulated circularly polarised (Stokes V) profiles of spectral lines. Two years later, an automatic tool (based on maximum entropy image reconstruction techniques) was developed and checked on a few test cases (Brown et al. 1991). In particular, this paper established that surface magnetic distributions consisting in circular regions of radially oriented field can be very well recovered with ZDI.

In the present paper, we show new simulations demonstrating that ZDI is good at reconstructing the *field orientation* within magnetic regions. In particular, it can always unambiguously identify azimuthal from radial/meridional field features (where radial, azimuthal and meridional refer to the three vector field components in spherical geometry). For high latitude magnetic spots, all three field components can be recovered. For low latitude regions however, ZDI (from circular polarimetry alone) suffers some crosstalk from radial to meridional field components (or vice versa), especially at low stellar inclination angles.

Accepted by A&AS

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More Light on RV Tau Variables

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This study confirms the results of the preliminary study (Russell, 1997) indicating that RV Tau variables in globular clusters don't show the kind of anomalous abundances seen in RV Tau variables observed in the field. By making comparisons with red giants in the same clusters, it has been possible, for the first time, to identify precisely how each element deviates from the normal abundance ratios of evolved giants.

The apparent systematic deficiency in s-process elements reported for RV Tau variables in the literature is not confirmed in the present study. Either the stars observed here are of such low metallicity, that what ever process causes s-process deficiencies in more metal rich field stars doesn't operate; or the systematic deficiency in s-process elements is simply an illusion of small number statistics.

Accepted by A&A

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Determination of the Globular Cluster and Halo Stellar Mass Functions and Stellar and Brown Dwarf Densities

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We use recent low-mass star models, which reproduce accurately the observed sequences of various globular clusters, to convert the observed luminosity functions into bolometric luminosity functions. These latter are shown to exhibit a similar behaviour with a rising slope up to $M_{bol} \sim 9$, i.e. $m \sim 0.2 - 0.3\,M_\odot$, and a decreasing behaviour beyond this limit. We then derive *mass functions* for globular star clusters down to the bottom of the main sequence. These mass functions are well described by a slowly *rising* power-law $dN/dm \propto m^{-\alpha}$, with $0.5 < \alpha < 1.5$, down to $\sim 0.1\,M_\odot$, independently of the metallicity, suggesting a rather universal behaviour of the cluster initial mass functions. The effects of tidal stripping and mass segregation are illustrated by the overabundance of very low-mass stars in the outer

parts of $NGC6397$ and their depletion in the central parts. We predict luminosity functions in the NICMOS filters in the stellar and in the brown dwarf domains for different mass functions and metallicities.

We apply these calculations to the determination of the mass function in the Galactic halo, including the DeVaucouleurs spheroid and the $1/r^2$ dark halo. We derive the slope and the normalization of the spheroid mass function which is well described by the afore-mentioned power-law function with $\alpha \sim 1.7 \pm 0.2$ down to 0.1 $M_\odot$, although a slowly decreasing mass function below $\sim 0.15\,M_\odot$ can not be excluded with the data presently available. Comparison with the Hubble Deep Field star counts is consistent with such a mass function and excludes a significant stellar population in the dark halo.

Consistent analysis with recent microlensing experiments towards the LMC shows that the spheroid and the dark-halo *stellar+brown dwarf* populations represent at most $\sim 1\%$ of the Galactic dark matter density. This clearly excludes brown dwarfs and low-mass stars as significant dark matter candidates.

Accepted in A&A

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Solar Abstracts

High Velocity Flows in an Active Region Loop System Observed With the Coronal Diagnostic Spectrometer (CDS) on SOHO

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EUV spectra of coronal loops above an active region show clear evidence of strong dynamical activity. We present an example where the O V 629 Å line, formed at 240 000 K, is shifted from its reference position corresponding to line of sight velocities greater than 50 km s^{-1} with the shift extending over a large fraction of a loop. The observations were made with the Coronal Diagnostic Spectrometer (CDS) on the Solar and Heliospheric Observatory (SOHO), and are from active region NOAA 7981 on the east solar limb on 27 July 1996. An animation has been prepared showing the variation of the shift or flow velocity along the loop. This animation is to be found on the enclosed CD-ROM and gives a clear impression of the dynamical condition present in the loop. The appearance of the loop system in different lines formed over a range in temperature as well as the observed dynamics indicates that loops at different temperatures are not closely co-located. Finally, the results are discussed and related to mechanisms that may cause line shifts.

Accepted by Solar Physics

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X-ray Network Flares of the Quiet Sun

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The temporal variations in the soft X-ray (SXR) emission and the radio emission above the solar magnetic network of the quiet corona are investigated using Yohkoh SXR images with deep exposure and VLA observations in the centimetric radio range. The SXR data show several brightenings with an extrapolated occurrence probability of one brightening per 3 seconds on the total solar surface. During the roughly 10 minutes of enhanced flux, the total radiative losses of the observed plasma are around 10^{25} erg per event. These events are more than an order of magnitude smaller than previously reported X-ray bright points or active region transient brightenings. For all of the four SXR events with simultaneous radio observations, a corresponding radio source correlating in space and time can be found. There

are several similarities between solar flares and the SXR/radio events presented in this paper: (i) The variations in temperature and emission measure during the SXR enhancements are consistent with evaporation of cooler material from the transition region and the chromosphere. (ii) The ratio of the total energies radiated in SXR and radio is similar to that observed in flares. (iii) At least one radio event shows a degree of polarization as high as 35%. (iv) In 3 out of 4 substructures, the centimetric radio emission peaks several tens of seconds earlier than the SXR emission. (v) The associated radio emission tends to be more structured and to have faster rise times. These events thus appear to be flare-like and are called network flares.

Accepted by ApJ

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For preprints via ftp or WWW: http://mimas.ethz.ch/papers/krucker/APJ1997/ApJ_1997.ps

On the Asymmetry of Solar Acoustic Line Profiles

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We study a simplified model of solar acoustic oscillations and show how asymmetries in spectral lines depend both on the acoustic source depth, as previously recognized, and on the acoustic source type. We consider several possible nonadiabatic effects and demonstrate how these do not explain the observed differences in velocity and intensity spectra, and argue more generally that any such effects are unlikely to explain that difference. Finally, we consider the differing background levels in the observed spectra and show how additive noise can change the apparent line profiles. This suggests a simple explanation for the differing asymmetries observed in the intensity and velocity spectra.

Submitted to ApJ

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Water on the Sun: Line Assignments Based on Variational Calculations

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The infrared spectrum of hot water observed in a sunspot is assigned. The high temperature of the sunspot (3200 K) gives rise to a highly congested pure rotational spectrum in the 10 μm region that involves energy levels at least half way to dissociation. Traditional spectroscopy, based on perturbation theory, is inadequate for this problem. Instead accurate, variational solutions of the vibration-rotation Schrödinger equation are used to make assignments which reveal unexpected features including rotational difference bands and fewer than anticipated degeneracies. The necessity of a first principles approach for a molecule such as water represents a paradigm shift in the theory of polyatomic molecular spectroscopy.

Accepted by Science

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Pre-announcement

The Non-Sleeping Universe

24 to 29 November 1997
Centro de Astrofísica da Universidade do Porto, Porto, Portugal

This conference is divided in two sub-conferences: *Stars and the ISM* and *From Galaxies to the Horizon*. The main objective is to provide astronomers with an opportunity to discuss different phenomena covering a wide range of scales - from stars to the observable horizon. For each sub-conference, topics include:

The Non-Sleeping Universe: Stars and the ISM
Date: 24–26 November 1997
Contact: `nsu-stars@astro.up.pt`

- Asteroseismology
- Stellar rotation and activity
- Time variability in young stars
- Stellar disks and winds
- Jets and outflows in the ISM

The Non-Sleeping Universe: From Galaxies to the Horizon
Date: 27–29 November 1997
Contact: `nsu-galaxies@astro.up.pt`

- Cosmological models and structure formation
- Cosmic microwave background
- Cosmological parameters: Λ, Ω_0 and H_0
- γ-ray bursts
- Active galactic nuclei and X-ray clusters

Scientific Organizing Committee: John Barrow (Sussex)*, Peter Brand (Edinburgh)*, Alexander Boksenberg (Cambridge), Giuseppa Fabbiano (Cambridge, USA), Gerald Fishman (NASA), Ricardo Giacconi (ESO), Jean Heyvaerts (Strasbourg), Teresa Lago (Porto), Anthony Lasenby (Cambridge), Paulo Macedo (Porto), Françoise Praderie (Paris), Eric Priest (St.Andrews), Martin Rees (Cambridge)*, Ian Roxburgh (London), Robert Williams (Baltimore)*

* to be confirmed

Local Organizing Committee: Pedro Augusto, Pedro Avelino, Jorge Carvalho, Amadeu Fernandes, Jorge Gameiro, João Lima, Mário Monteiro, António Pedrosa

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Ph.D. Studentship Opportunity
Univ. of Vienna

A three year PhD-thesis position is available at the Inst. for Astronomy of the University of Vienna, supported by the Austrian Science Foundation. The topic of the thesis is in the field of Doppler imaging of late-type stars and is part of an ongoing program including one postdoc (currently Dr. Yvonne Unruh), four other PhD students and one master's student.

Payment is 13,000 ATS per month (approx. 1080 USD) for up to three years. Candidates should e-mail to strassmeier@astro.ast.univie.ac.at or phone in at +43-1-4706800-80 after June 16th to discuss further details.

Contact: K. G. Strassmeier Institute for Astronomy University of Vienna Tuerkenschanzstrasse 17 A-1180 Wien, Austria http://www.ast.univie.ac.at/~kgs/StellarActivity.html

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. The subject matter should pertain directly to cool stars (spectral types F,G,K, or M) or the sun. Both theoretical and observational abstracts are appropriate. Abstracts dealing with cool pre-main-sequence 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. 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 .`