COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 7 — April 1996 Editor: Steve Skinner (coolnews@jila.colorado.edu)

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From the Editor

Latex Quirks: Some people encountered an error when attempting to run Latex on the March issue due to the presence of a **mathrm** command. This command will not produce an error if you are using the most recent version of Latex (Latex 2ε), but since it is a new command it will not compile with the previous version (Latex 2.09). I will attempt to catch such compatibility problems before I send out future issues of the newsletter. However, if you do encounter a Latex error then simply ignore the Latex file and grab the PostScript file directly off of the COOLNEWS Home Page: http://casa.colorado.edu/∼skinners/coolnews.html .

The Mysterious Case of the Missing Tildes: If you are supplying a Web Page URL with your abstract, please exercise caution with special characters such as the tilde. If you simply type in a tilde character from the keyboard, it will print out as a *blank space* in the newsletter. You will soon realize that this has happened when you receive an e-mail overload from confused readers who cannot connect to your Web-page URL. As a substitute for the keyboard tilde, you can use the math-mode symbol **sim** ($\sim$). If your abstract contains special Latex characters or specially-defined symbols, it's worthwhile to Latex it and look at it on your home machine before submitting it.

The Distribution of Rotational Velocity for Evolved Stars

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In this work we present the distribution of the projected rotational velocity V_{sini} for evolved stars of luminosity classes IV, III and II. Such a distribution is studied as a function of the color index and the spectral type for a large sample of about 1400 stars, with spectral types ranging from middle F to middle K, complete to magnitude 6.5. We show essentially that F giant stars present a broad distribution of V_{sini} values, whereas G and K giants present strikingly similar distributions reaching a maximum at very low values and decreasing abruptly with increasing V_{sini} values. The mean rotational velocity is given as a function of the color index and spectral type.

Submitted to A&A

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Synthetic Spectra and Mass Determination of the Brown Dwarf Gl229B

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We present preliminary non-grey model atmospheres and interiors for cool brown dwarfs. The resulting synthetic spectra are compared to available spectroscopic and photometric observations of the coolest brown dwarf yet discovered, Gl229B (Nakajima *et al.* 1995). Despite recognized shortcomings of current methane opacities, we find that the model spectra provide an excellent fit to most of the spectral features of the brown dwarf. We confirm the presence of methane absorption and the substellar nature of Gl229B. These preliminary models set an upper limit for the effective temperature of 1000 K. We also compute the evolution of brown dwarfs with solar composition and masses from 0.02 to 0.065 $M_\odot$. While uncertainties in the age of the system yield some undetermination for the mass of Gl229B, the most likely solution is $m \approx$ 0.04-0.055 $M_\odot$. In any case, we can set an upper limit $m=$ 0.065 $M_\odot$ for a very unlikely age $t = 10$ Gyr.

Submitted to ApJ Letters

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RS CVn vs. ALGOL-type Binaries : A Comparative Study of their X-ray Emission

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We have compiled a list of 59 RS CVn binaries and 29 Algol-type binaries with well-known orbital parameters and which have been observed with the *ROSAT* PSPC detector in order to find out whether there is any detectable influence of mass transfer on the X-ray emission properties of these two types of active binaries. If there were, one might expect the RS CVn binaries (which typically are expected to have negligible mass exchange) and the semi-detached 'Algol' binaries (which have well-established mass exchange between the two components) to exhibit systematic differences in the X-ray region. We have studied the statistical correlations between (a) the X-ray luminosity (L_x) and the Roche-lobe filling fraction (Γ_2) for the active star, (b) L_x and the rotation period (P), and (c) the X-ray surface flux (S_x) and P. In general, we find that the RS CVn and Algol binaries do not have similar L_x distributions. There is a tendency for the Algol binaries to be ~3–4 times less luminous compared to RS CVns with the same period. This is the exact opposite of what might have been expected if mass transfer rates influenced X-ray emission levels, since in that case the Algol binaries would be more X-ray luminous than the RS CVn binaries. A highly significant correlation is found between log S_x and log P in both of the two types of binaries, while a weak correlation that is observed between log L_x and log Γ_2 in the RS CVn binaries is likely to be due to correlations of these quantities with the stellar radii.

Accepted by AJ

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COYOTES III: Observational Evidence for a *Lower* Limit to the Rotational Velocity of ZAMS G and K dwarfs

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In order to provide additional constraints to current models of angular momentum evolution of solar-type stars, we have conducted a period-determination program in the Alpha Perseus cluster. We have selected a sample of 22 Alpha Persei G and K dwarfs on the basis of their seemingly slow rotation rate ($v\sin i \leq 10$ km s^{-1}). We searched for periodic modulation induced by stellar spots by performing a photometric CCD monitoring campaign in the V band over a baseline of 14 days. We detected 10 periods ranging from 1.3 to 7.1 days. A period was found for 7 out of the 10 K stars of our sample but for only 3 out of the 12 G and F stars. This bias is due to the existence of a clear relationship between spectral type and the amplitude of modulation by spots. We show that our study is not biased against the detection of very slow rotators and conclude to the existence of a lower limit of about 6 km s^{-1} for the rotational velocity of Alpha Per G and K dwarfs. A significant fraction of solar-type stars in young clusters thus appear to have equatorial velocities distributed in a very narrow range between about 6 and 10 km s^{-1}, a result which poses a severe constraint to current models of angular momentum evolution.

Accepted by A&A

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

HD 106225 = HU Virginis: Source of Gamma-Ray Burst GRB 930131?

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The Compton Gamma-Ray Observatory (CGRO) detected its most intense gamma-ray burst to that time on 1993 January 31 UT. HD 106225, one of the most active chromospherically active stars, lies within the positional error box of that burst. Subsequent searches of the region inside the error box led to the claim that HD 106225 was in an unusually active state several weeks after the burst and so was probably the source of GRB 930131. We examine seven years of photoelectric photometry acquired with the Vanderbilt/Tennessee State 0.4 m automatic telescope, including observations shortly before and after the gamma-ray burst, and demonstrate that there is no photometric evidence to support the claim that HD 106225 is the source of GRB 930131.

Submitted to PASP

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Fundamental Limitations of Emission Line Spectra as Diagnostics of Plasma Temperature and Density Structure

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We discuss the problem of determining plasma structure from optically thin emission lines whose emission coefficients and frequency-integrated intensities are dependent on temperature T and electron density n. We cast the problem into the inverse form discussed by Hubeny & Judge (1995).

Three properties of the kernels in the integral equations lead to fundamental limitations in trying to determine the source term $\mu(T,n)$, the "emission measure differential in temperature and density", from a set of emission line intensities. First, the kernels are rather weakly dependent on n. Second, they have asymptotically identical dependences on n. The inverse problem is therefore very poorly conditioned in the density dimension. Third, the kernels cannot (and may never) be calculated with an accuracy better than $\pm 10\%$. These properties set limits on the accuracy of *all* solutions, independent of the accuracy of observed line intensities. This concurs with earlier but less general work by Brown et al. (1991).

We try to determine solutions for $\mu(T,n)$, using specific target sources and numerical algorithms. Using realistic uncertainties, calculations indicate that meaningful inverse solutions for $\mu(T,n)$ cannot be obtained owing to the severe propagation of kernel errors, irrespective of the quality of observational data. Solutions for the "emission measure differential in temperature" $\xi(T) = \int \mu(T,n)dn$ are more robust against instabilities driven by poor conditioning.

Since traditional "emission line diagnostic ratios" can only be defined through $\mu(T,n)$ (or some generalization thereof), our analysis casts doubt on the meaning of plasma properties derived from such line ratios, and illustrates the severe non-uniqueness of any equivalent "inverse" solution.

This work is likely to be important for studies attempting to use inverse methodology applied to a wide variety of atomic and ionic emission line spectra.

Submitted to ApJ

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Constraints On The Use Of Be I Lines For Deriving Beryllium Abundances In Late-Type Dwarf Stars

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Beryllium is a key element for constraining mixing processes taking place in the interiors of late-type dwarfs, and this paper investigates the use of neutral beryllium lines to obtain reliable abundances. The best candidate, among other Be I features, is the ^{9}Be I λ 2348.609 Å resonance line. Its spectral location, well below the Earth's UV transmission limit, implies its observation with satellites (at the present time the *Hubble Space Telescope* - HST). Synthetic spectra of this region, with different beryllium abundances, were computed for a cool star previously studied using the Be II λ 3131.065 Å line (which provided only an upper limit to its beryllium abundance). The low sensitivity shown by the feature associated with the Be I line to changes as large as three orders of magnitude in the beryllium abundance, the poor knowledge of the atomic and molecular line-data in the relevant spectral region, and the limited signal-to-noise ratios associated with the restricted exposure times of the HST prevent the use of this line for abundance analysis purposes. This result is generally applicable to dwarf stars in the effective temperature range 4800–5800 K. A detailed knowledge of the lines present in the spectral region considered would be essential for improving this situation. However, a similar improvement in the data for the lines surrounding the Be II λ 3131.065 Å line (which is more isolated and can be observed from ground-based telescopes) would be probably much more useful.

Accepted by A&A (Research Notes)

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For preprints via ftp or WWW: http://www.iac.es/publicaciones/publi.html

Goddard High Resolution Spectrograph Observations Of Variability In The RS CVn System V711 Tau (HR 1099)

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Goddard High Resolution Spectrograph (GHRS) observations of the RS CVn-type binary V711 Tau (K1 IV + G5 IV) were obtained at several phases over two consecutive stellar orbital cycles in order to study ultraviolet emission line profile and flux variability. Spectra cover the Mg h- and k-lines, C IV doublet, and Si IV region, as well as the density-sensitive lines of C III (1909 Å) and Si III (1892 Å). IUE spectra, EUV data and *UBV* photometry were obtained contemporaneously with the GHRS data. Variable extended wings were detected in the Mg II lines. We discuss the Mg II line profile variability using various gaussian emission profile models. No rotational modulation of the line profiles was observed, but there were several large flares. These flares produced enhanced emission in the extended line wings, radial velocity shifts, and asymmetries in some line profiles. Nearly continuous flaring for more than 24 hours, as indicated in the IUE data, represents the most energetic and long-lived chromospheric and transition region flare ever observed with a total energy much greater than 5×10^{35} erg. The C III/Si III line ratio is used to estimate the plasma density during the flares.

Submitted to ApJ

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A TiO-Constrained Doppler Image of II Pegasi

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We have developed a technique in which the 7055 and 8860 Å absorption bands of the TiO molecule are used to measure starspot area and temperature on active stars. Here we describe how TiO band spectroscopy can be used in conjunction with Doppler imaging to completely determine the photospheric temperature distribution of rapidly rotating, active stars. We apply a simplified version of this technique to the star II Pegasi, and we find that Doppler imaging constrained by TiO band spectroscopy yields an average spot temperature ≈ 350 K cooler than that given by Doppler imaging alone.

Submitted to ApJ Letters

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Long-term Monitoring of Active Stars – V. UBV(RI)$_c$ Photometry Collected in Feb-Mar 1990

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High-precision UBV(RI)$_c$ photometry of 12 active stars, collected at the European Southern Observatory over the period February - March 1990, 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. Some of the spectral classifications are discussed.
The stars observed are: HD 26354 = AG Dor, HD 45088 = OU Gem, HD 82558 = LQ Hya, HD 98712 = SZ Crt, HD 101309 = V829 Cen, HD 102077 = V838 Cen, HD 106225 = HU Vir, HD 119285 = V851 Cen, HD 127535 = V841 Cen, HD 136905 = GX Lib, HD 139084 = V343 Nor, HD 155555 = V824 Ara.

Accepted by A&AS

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Distribution of Starspots on Cool Stars I. Young and Main Sequence Stars of $1\,M_\odot$

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Sunspots are restricted to a latitude band within 30 deg of the solar equator. In contrast, the latitudes of spots on the surfaces of rapidly rotating cool stars can range from their polar regions, for RS CVn systems and for T Tauri stars leaving the Hayashi track, to mid latitudes for stars close to or on the main sequence. In order to find an explanation for these observed spot latitudes we have applied the criteria for the undulatory instability (Parker instability) of a toroidal magnetic flux tube embedded in the convective overshoot layer below the outer convection zone and calculated the non-linear evolution of the rising magnetic loops formed by this instability. We describe the results for a star of one solar mass in different phases of its evolution before and on the main sequence. We find that there usually is a range of latitudes at which magnetic flux can emerge on the stellar surface. The mean latitude of emergence shifts towards the poles for increasingly rapid rotation. The internal structure of the star, however, plays an almost equally important role in determining the latitude of magnetic emergence. For stars of solar mass only the youngest objects, with extremely deep convection zones, should show spots emerging at the stellar poles. Pre-main sequence stars at an age of 10^7 y (convection zone reaching down half-way to the centre) exhibit high latitude, but not truly polar spots, while a main sequence star of one solar mass, even at high rotation rates, only shows intermediate latitude spots. These results are found to be in good agreement with Doppler images of young rapid rotators.

Accepted by A&A

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First Image of the Surface of a Star with the Hubble Space Telescope

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A direct image of the surface of a star, *Betelgeuse* (Alpha Orionis; M2 Iab) has been obtained with the Faint Object Camera on the Hubble Space Telescope. Images in two ~300Å wide bands centered at λ 2550 and λ2800 cover about 10 resolution elements on the stellar disk. The ultraviolet diameter of *Betelgeuse* of 125 ±5 milliarcsec at λ2500 (corresponding to 108 ±4 milliarcsec, FWHM) is a factor of 2.2 larger than the optical diameter thus indicating a substantially extended chromosphere in the supergiant. A single bright unresolved area is present in the southwest quadrant of the disk (PA = 235deg) in both images with a peak amplitude of 1.3 to 1.8 as compared to the surrounding disk, and a temperature differential in excess of 200K. This feature might result from magnetic activity, atmospheric convection, or global pulsations and shock structures that heat the chromosphere. Spatially resolved spectroscopy of

the Mg II (λ2800) doublet with the GHRS suggests complicated dynamics with outflowing material in the chromosphere indicated by the Mg II emission.

Accepted by ApJ Letters (May 20, 1996 issue)

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For preprints via ftp: ftp 131.142.10.30, cd pub/dupree

Chromospherically Active Stars. XV. HD 8357 = AR Piscium, An Extremely Active RS CVn System

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One of the first x-ray sources optically identified as a chromospherically active star, HD 8357 = AR Piscium is a double-lined binary consisting of a K1 IV primary and G7 V secondary. Careful examination of the Ca II H and K lines indicates that only the primary is active, having strong Ca II H and K, Hϵ, and Hα emission. The system has an orbital period of 14.3023 days and an eccentricity of 0.185. Such an eccentricity is not particularly unusual for chromospherically active stars with periods between 10 and 20 days. An assumed mass of 0.92 $M_\odot$ for the secondary results in 1.12 $M_\odot$ for the subgiant primary and an orbital inclination of 30°. Projected rotational velocities for the primary and secondary are 6.5±2 km s^{-1} and 3.5±2 km s^{-1}, respectively. Lithium abundances for the two stars are significantly different with log ϵ(Li)=2.0 for the primary and $\leq$1.35 for the secondary. While the abundance for the subgiant is consistent with standard theory, comparison with a survey of other field subgiants suggests that it may be lithium rich. Individual theoretical evolutionary tracks and cluster ages suggest an age of 7-8 Gyr. HD 8357 is a star of the intermediate-disk population having a distance of 39 pc or a parallax of 0.026″.

Accepted by AJ (July '96 issue)

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Upcoming Meetings

Stellar Oscillations Network Group: From the Sun to the Stars

A Special Session at Madison Meeting of the AAS, 9-13 June, 1996

The detection and study of oscillations in solar type stars is a natural extension of the scientific goals of helioseismology. In view of the recent encouraging developments in asteroseismology and the announcement of the first results from the initial operation of the full GONG network at the Madison AAS meeting, it is time to develop a coordinated, community wide effort to achieve the potential that asteroseismology offers for progress in stellar physics, stellar structure, and stellar evolution. An effort of this magnitude can only succeed if it is truly community based.

We propose the formation of a broad, community based project with the goals of obtaining coordinated seismic observations of astrophysically important stars and, if necessary, of developing and deploying any specialized instrumentation that might be needed. While the focus is on solar type stars, we hope to draw on the experience and expertise of groups working on other classes of non-radially oscillating stars. Ultimately, the data produced through this program should return to the community.

As a first step, a steering committee, whose members are John Bahcall, Sam Barden, Tim Bedding, Tim Brown, Pierre Demarque, Mark Giampapa, Ron Gilliland, Jack Harvey, Frank Hill, Steve Kawaler, Christoph Keller, Hans Kjeldsen, Bob Noyes, and Caty Pilachowski, is organizing a special session at the Madison meeting of the American Astronomical Society this June. The session will be held from 2:00 until 3:30 on Monday, June 10. The goals of this Special Session are 1) to inform the community about the project and to invite participation, and 2) to establish a framework for further discussions leading to a better understanding of what observational approach, what instrumentation, and what facilities might most fruitfully be applied. The program will include reviews of recent results and instrumental possibilities.

For further information, please contact C. Pilachowski at catyp@noao.edu, or visit our Web site via http://www.noao.edu (click on "S.O.N.G.").

Solar and Stellar Activity Cycles

by Peter R. Wilson (Univ. of Sydney)

This is the 24th monograph in the distinguished Cambridge Astrophysics Series and attempts to synthesize our present knowledge of activity cycles in the sun and other stars. It is fitting that this volume should be authored by an astronomer named Wilson, given the lengthy association of this name with studies of solar-stellar activity (i.e. Wilson-Bappu relation, Wilson depression, Wilson effect, Olin Wilson, Alexander Wilson, R.M. Wilson, and of course Mount Wilson).

The book can be informally divided into three parts: (i) an introduction to solar and stellar activity, including historical material (ch. 1-7), (ii) a detailed description of solar activity and the underlying role of the dynamo (ch. 8-11), and (iii) new research frontiers (ch. 12-14). The focus of the book is primarily on solar activity because of its historical role and the extensive solar data record. The reader who is interested mainly in the field of stellar activity may feel a bit short-changed, since only one chapter is devoted to this flourishing subject.

I particularly enjoyed going through the first seven chapters, which have the flavor of a major review article. These seven chapters would provide an excellent introduction to the subject of solar-stellar activity for graduate students and non-specialists. Each chapter is followed by an extensive and up-to-date reference list, and the author takes special care to cite review articles that can be consulted for more in-depth reading. Some lesser known articles are also cited, such as "Dull and Dull 1934", which may sound like boring reading but actually makes the bizarre claim that human mortality is correlated with sunspot number (...not supported by modern studies!).

As with most books, this one has a few shortcomings. In particular, I noticed some major omissions in the chapter on stellar activity. For example, there is no discussion of the dividing line, an observational discovery that may ultimately play a fundamental role in our understanding of the dynamo and surface activity in evolved stars. There are also some obvious signs of editorial corner-cutting. Specifically, the Table of Contents is set in a monotonous single-spaced typeface that runs on for five pages and is very difficult to skim.

Although this monograph may not provide much new material for active researchers in solar-stellar activity, I would strongly recommend it for graduate students or non-specialists who are coming up to speed and want a broad overview of the subject.

Chapter Headings: 1) Introduction 2) Historical Survey 3) The Structure of the Sun and the Phenomena of Activity 4) The Equations of MHD and Magnetohydrostatics 5) The 1D Configuration of the Cycle 6) Heuristic Models of the Solar Activity Cycle 7) Stellar Activity and Activity Cycles 8) The 2D Representation of the Extended Activity Cycle 9) The Origin of the Large-Scale Fields 10) The Reversal of the Polar Magnetic Fields 11) The Role of Dynamo Theory in Cyclic Activity 12) Helioseismology and the Solar Cycle 13) Cyclic Activity and Chaos 14) Forecasting the Solar Cycle 15) Summary and Conclusions

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Submitted by Steve Skinner

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` .