COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Editor's Note

COOLNEWS is now well into its second year of publication and I would like to thank all of you who have taken the time to send in abstracts and other material. It is particularly pleasing to receive timely abstracts from such places as the FSU countries (as in this issue), giving many of us a rare glimpse of what is happening outside of the U.S. and western European communities.

I would like to remind everyone that COOLNEWS is posted monthly on the World-Wide-Web in both PostScript and Latex format. Back issues can be retrieved. The WWW address is

`http://casa.colorado.edu/~skinners/coolnews.html` .

Because of the upcoming year-end holidays and AAS meeting, COOLNEWS will take a break with *no issue planned for January.* Abstracts for the February '97 issue are due Jan. 31. Enjoy the holidays and best wishes for the New Year. Sincerely, Steve Skinner

UV Spectroscopy of AB Doradus with the Hubble Space Telescope: Impulsive Flares, Bimodal Profiles and Doppler Images of the CIV 1550 Line in a Young Star

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We observed AB Doradus, a young and active late type star (K0 - K2 IV-V, P = 0.514 d) with the Goddard-spectrograph of the post-COSTAR *Hubble Space Telescope* on November 14.08 - 14.30, 1994 (UT). The grating G160M was used with time and spectral resolution of 25 s and 15 km/s. respectively. The wavelength band (1531 - 1565 Å) included the strong CIV doublet (1548.202 and 1550.774 Å , formed in the transition region at 10^5 K), the chromospheric SiII 1533.432 Å line and the blend of SiI, CI and FeII lines at 1561 Å . The quiescent state of AB Dor is characterized by the CIV-line surface flux $F_{CIV} = (7.80 \pm 0.34) \times 10^5$ erg cm^{-2} s^{-1}, close to the saturated value and 100 times the solar one. The line profile is bimodal consisting of two Gaussians, narrow (FWHM = 70 km/s) and broad (FWHM = 330 km/s). This bimodality is probably due to two separate broadening mechanisms and velocity fields at the coronal base, giving possibly the energy to its heating and even to the observed 2-temperature corona with compact and extended loops. It is possible that TR transient phenomena (multiple velocities) with a large surface coverage give rise to the broadening of the narrow component, while true microflaring is responsible for the broad one. The Doppler-image of the CIV-plages is a remarkable mirror-image of the simultaneous spot-image (MUSICOS campaign), indicating that one of the magnetic poles was covered with spots, while the other one had closed magnetic field structures (coronal loops) with an enhanced CIV-emission not associated with spots. This might mean that the magnetic poles can be filled either with plages or spots, but not simultaneously with both of them. The transition region is flaring frequently on different time scales and magnitudes; even the quiescent level might be due to many overlapping microflares. The star spends 15 per cent of time outside the 3σ-level from the mean quiescent state. The largest impulsive flare seen in the CIV 1550 Å emission at day 14.22 reached in 25 seconds a differential emission measure of $10^{51.2}$ cm^{-3} (= N_e^2 V between $10^{4.85}$ K - $10^{5.15}$ K) and returned to the 7 times lower quiescent level with a 100 s decay time. The total energy of the flare radiated in the CIV 1550 Å line was $(1.65 \pm 0.10) \times 10^{31}$ erg. This is 30 - 60 times stronger than the strong solar CIV-flare observed with the SOLSTICE (Brekke et al 1995). The 3 min average line profile of the flare was blue-shifted (-190 km/s) being very broad with FWHM = 800 km/s. This impulsive flare can be modelled with a chromospheric heating (and subsequent evaporation) by an electron beam accelerated (by reconnection) at the apex of a coronal loop, using the hydrodynamics by Mariska et al. (1989). The flaring loop foot point area covered 0.5 - 1.0 per cent of the total stellar surface with 10^{40} injected electrons. A volume of 10^{30} cm^3 is a minimum estimate for the acceleration volume; this can be the apex region of a relatively compact coronal loop.

Based on observations with the NASA/ESA *Hubble Space Telescope*, obtained at the Space Telescope Science Institute which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA Contract NAS5-26555.

Submitted to AJ

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For preprints via ftp: anonymous ftp from astar.helsinki.fi , the directory scratch2/ftp/pub/vilhu , files: vilhu.ps (text), vilhu.tab1.ps and vilhu.tab2.ps (2 tables), and 10 figures: vilhu.fig*.ps where * = 1,2,3,4a,4b,5a,5b,6,7,8

Infrared Stellar Absorption Lines Around 1.6 μm: A New Metallicity Scale for Old Stellar Populations

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A new metallicity scale (accurate to within ±0.3 dex) for old stellar systems is derived and discussed. It is particularly useful in cool objects with [Fe/H]>−1.3 and is based on medium resolution (R≃2000) near infrared spectra of a deep and relatively isolated feature at 1.62 μm which is mostly due to the CO(6,3) second overtone band-head. The value of [Fe/H] can be determined using handy interpolation formulae (Eqs. 1a, 1b and Eq. 2) and is little influenced by anomalies of the carbon abundance, [C/Fe], since the growth of $W_\lambda(1.62)$ with metallicity primarily tracks variations of stellar temperature and gravity, rather than the increase of the total carbon abundance.

The method is tested using IRSPEC observations of 13 well known globular clusters where the derived [Fe/H] values are in good agreement with the results of Zinn (1985) for all but two objects, namely NGC6624 and Terzan 5, which we find much less (≃0.9 dex) metallic (first two columns of Table 1 and Fig. 5). Ellipticals are found to have [Fe/H] of about −0.4 and ∼0.5 dex below estimates based on the Mg_2 index, this indicates that Mg may be overabundant by a similar amount. A ∼0.5 dex enhancement of Si (another α element) is also suggested by the strength of the 1.59 μm line in our spectra. The only object with [Fe/H]≥0.0 is the globular cluster Terzan 1.

Accepted by A&A

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Time-series Photometric Spot Modeling III. Thirty Years in the Life of HK Lacertae

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We present a spot modeling analysis of the active late-type giant HK Lac using 30 years of photometry, including 600 new data points from the last six years. We have analyzed folded light curves and, when we had long continuous data sets, applied a new computer code for time-series modeling. The validity of the modeling results was tested as a function of the photometric noise. We have determined the unspotted brightness of HK Lac in the $BV(RI)_C$ bandpasses and obtained a spot temperature of $\Delta T = 1200 \pm 100$ K. Polar active regions were recovered throughout the modeling because no other scenario was able to describe both the mean light variability of over 0.25 mag. accompanied by rotational modulation of similar amplitude. This result has gotten strong theoretical support recently (see Schüssler [1996], in *Stellar Surface Structure*, IAU Symp. 176, p. 269). The active regions preferably cluster around two orbital phases separated by $\approx 110°$. New spot appearances within active regions and, possibly, their interactions with the old ones could be the cause of rapid changes in the light curves.

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Modeling Li I and K I Sensitivity to Pleiades Activity

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We compare schematic modeling of spots and plage on the surface of cool dwarfs with Pleiades data to assess effects of magnetic activity on the strengths of the Li I and K I resonance lines in Pleiades spectra. Comprehensive Li I and K I NLTE line formation computation is combined with comparatively well-established empirical solar spot and plage stratifications for solar-like stars. For other stars, we use theoretical constructs to model spots and plage that portray recipes commonly applied in stellar activity analyses. We find that — up to $B-V \approx 1.1$ — neither the Li I 670.8 nm nor the K I 769.9 nm line is sensitive to the presence of a chromosphere, in contrast to what is often supposed. Instead, both lines respond to the effects of activity on the stratification in the deep photosphere. They do so in similar fashion, making the K I line a valid proxy to study Li I line formation without spread from abundance variations. The computed effects of activity on line strength are opposite between plage and spots, differ noticeably between the empirical and theoretical solar-like stratifications, and considerably affect stellar broad-band colors. Our results indicate that one can neither easily establish, nor easily exclude, magnetic activity as major provider of K I line strength variation in the Pleiades. Since Li I line formation follows K I line formation closely, the same holds for Li I and the apparent lithium abundance.

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The Gas-dynamic Model of Impulsive Stellar Flares

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We investigate the response of a plasma in a magnetically confined loop to intense impulsive energy release during stellar flares. We carry out a numerical simulation of gas-dynamic processes in an approximation to a single-fluid, two-temperature, plasma with a possible distinction between the ion and electron temperatures taken into account. We present here results of the modelling for an initial model of the red dwarf atmosphere including the photosphere, the chromosphere, the transition region and the corona. Tenuous layers of the upper chromosphere, which usually exist in quiescent regions on red dwarfs are also included in this initial model. This is a fertile field for development of our understanding of the process of explosive evaporation.

Heating of the plasma is due to a hard electron beam with an energy of $3 \cdot 10^{11}$ erg cm^{-2} s^{-1}; this value is based on an analysis of the soft X-ray data for stellar flares. The use of a new numerical technique reveals basic features of the gas-dynamic processes for a single, elementary, heating lasting 10 s. In the first 0.1-0.2 s, the plasma is heated strongly in the upper chromospheric layers, followed by two disturbances which subsequently propagate downward and upward from the high-pressure region formed. A flow quickly follows, with a temperature jump which moves slowly downwards, and ahead of which travels a radiative shock wave. Also, hot gas moves outwards from the region of the temperature jump. Modelling allows us to determine the physical conditions at the source of the emission in different spectral regions, and, in particular, it provides evidence for the thermal origin of optical emission from stellar flares.

We discuss possibilities for the interpretation of observational data of real stellar flares which consist of a set of elementary events. This modelling has the advantage that the behaviour of the optical, EUV and soft X-ray radiation can be explained simultaneously.

Our gas-dynamic modelling may be applied to impulsive stellar flares with amplitudes $\Delta U < 3^m$, i.e. until thermal conduction fluxes are smaller than the saturated ones and the return current doesn't limit the penetration of accelerated electrons into the chromosphere.

Accepted by A&A

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The Discovery of a Planetary Companion to 16 Cygni B

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High precision radial velocity observations of the solar-type star 16 Cygni B (HR 7504, HD 186427), taken at McDonald Observatory and at Lick Observatory, have each independently discovered periodic radial-velocity variations indicating the presence of a Jovian-mass companion to this star. The orbital fit to the combined McDonald and Lick data gives a period of 800.8 days, a velocity amplitude (K) of 43.9 $\mathrm{m\,s^{-1}}$, and an eccentricity of 0.63. This is the largest eccentricity of any planetary system discovered so far. Assuming that 16 Cygni B has a mass of $1.0\mathrm{M}_\odot$, the mass function then implies a mass for the companion of $1.5/\sin i$ Jupiter masses. While the mass of this object is well within the range expected for planets, the large orbital eccentricity cannot be explained simply by the standard model of growth of planets in a protostellar disk. It is possible that this object was formed in the normal manner with a low eccentricity orbit, and has undergone post-formational orbital evolution, either through the same process which formed the "massive eccentric" planets around 70 Virginis and HD114762, or by gravitational interactions with the companion star 16 Cygni A. It is also possible that the object is an extremely low mass brown dwarf, formed through fragmentation of the collapsing protostar. We explore a possible connection between stellar photospheric Li depletion, pre-main sequence stellar rotation, the presence of a massive proto-planetary disk, and the formation of a planetary companion.

Submitted to ApJ

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M-Subdwarfs: Spectroscopic Classification and the Metallicity Scale

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We present a spectroscopic classification system for M-dwarfs and M-subdwarfs based on quantitative measures of TiO and CaH features in the region $\lambda\lambda 6200-7400\mathring{A}$. Our sample of cool stars covers the range from solar metallicity stars to the most extreme subdwarfs known. Using synthetic spectra computed by Allard and Hauschildt (1995), we derive metallicities for the stars. Stars are classified as dwarfs (M V), subdwarfs (sdM), or extreme subdwarfs (esdM). These classifications correspond to $[m/H] \approx$ 0.0, -1.2, and -2.0 respectively. Our metallicity scale agrees with theoretical HR diagrams and HST globular cluster measurements. We discuss some nearby subdwarfs of particular interest in light of our metallicity scale.

Accepted by AJ

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The Na I $\lambda\lambda$5890,5896 Resonance Doublet as Chromospheric Diagnostics in M Dwarfs

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The Na I D lines at 5890/5896 Å are very prominent features in the spectrum of late-type stars. Nevertheless, little attention has been devoted to the potential use of those lines as chromospheric diagnostics. As a case study, we explore the dependence on chromospheric activity of the D lines in a star with $T_{\rm eff} = 3700$ K, $\log g = 4.7$ and solar metallicity. The results are compared with the better studied hydrogen spectrum. We find that the D lines seem to be a promising diagnostic of the lower-middle chromosphere, that can complement the information given by lines like Hα. We also find that, for detailed quantitative studies, it is necessary to include a proper treatment of the background opacities.

Less important, instead, is the need of careful treatment of transitions induced by collisions with hydrogen atoms. Finally, our calculations make it clear that, for the most active stars, the level of coronal emission should also be taken into account.

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Solar Abstracts

Is the Solar Cycle Timed by a Clock?

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Dicke (1978) has argued that the phase of the solar cycle appears to be coupled to an internal clock: shorter cycles are usually followed by a longer one, as if the Sun remembers the correct phase. The data set is really too short to demonstrate the presence of a phase memory, but phase and amplitude of the cycle are strongly correlated for 300 yr or more. It is shown that this memory effect can be explained by mean field theory in terms of fluctuations in α, which induce coherent changes in the frequency and amplitude of a dynamo wave. It is concluded that there is neither a strong observational indication nor a theoretical need for an extra timing device, in addition to the one provided by dynamo wave physics.

Dedicated to: Cornelis de Jager.

Accepted by Solar Physics

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Atomic Data Bases

CHIANTI - An Atomic Database For Emission Lines
Paper I: Wavelengths greater than 50 Å

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[4] Arcetri Astrophysical Observatory, Florence, Italy

A comprehensive set of accurate atomic data is required for analyses of astrophysical and solar spectra. CHIANTI provides a database of atomic energy levels, wavelengths, radiative data and electron excitation data for ions which are abundant in cosmic plasmas. The most recent electron excitation data have been assessed and stored following the method of Burgess and Tully (1992). The current version is essentially complete for specifying the emission spectrum at wavelengths greater than 50 Å. A list of observed lines in the spectral region between 50 and 1100 Å has been compiled and compared with the lines predicted by the CHIANTI database. The CHIANTI database reproduces the vast majority of lines observed at these wavelengths. CHIANTI includes IDL (Interactive Data Language) routines to calculate optically thin synthetic spectra for equilibrium conditions. IDL routines to calculate theoretical line intensities required for electron density or temperature diagnostics and emission measure studies are also included. The CHIANTI atomic database and supporting IDL routines are available by anonymous FTP.

Accepted by A&A

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Ph.D. Thesis Abstract

Spectral Emission from High-Temperature Plasmas

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Ph.D dissertation directed by: Francis P. Keenan and Kenneth J. H. Phillips

Ph.D degree awarded: November 1996

This thesis describes the observation and analysis of X-ray spectra from high temperature, low density, solar coronal plasmas. Theoretical spectra were formed from the most accurate atomic data available and used in conjunction with observations to derive various plasma parameters.

Solar flare and active region observations were obtained with the *Yohkoh* spacecraft and the *Solar Maximum Mission.* Synthetic spectra were also compared to independently diagnosed laboratory spectra to verify the accuracy of the theory. Details of the physical conditions in the solar atmosphere, such as the electron temperature, the electron density, and the geometery of the emitting region, are deduced.

Chapter headings: 1–Introduction; 2–Satellite instrumentation; 3–Analysis of Fe XVII X-ray Emission Lines; 4–Helium-like Sulphur X-ray Emission; 5–Properties of Solar Flares Determined from Mg XI X-ray Spectra; 6–Future work.

Thesis-related Publications: ApJ, 469, L57; Irish Astr. J., 22(2), 197; A&A, 306, 670.

Ph.D. Thesis Abstract

Modelling of Circumstellar Environments around Carbon and Oxygen-rich Stars

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Ph.D dissertation directed by: J.G. Doyle

Ph.D degree awarded: December 1996

In this work we investigate the nature of the dust shells around evolved late-type stars. We solve the problem of the transport of the radiation in a spherically symmetric medium, and we model the observed spectral energy distribution of a selection of asymptotic giant branch stars.

We studied in detail the diagnostic content of the spectral analysis, and developed an algorithm for finding the best-fit to the observational data. We gathered from the literature the extinction coefficients for a large sample of materials prepared as laboratory analogues of the circumstellar dust grains. We observed a selection of carbon and oxygen-rich stars, taking broadband photometry in the optical, near-IR and sub-millimetre, and low-resolution spectra in the mid-IR. We analysed the observed SEDs, paying particular attention to the following problems.

1) Although it is widely accepted that the dust grains in the circumstellar environments of oxygen-rich stars are of silicate, the precise nature of such "astronomical silicate grains" is still far from clear. Recently, several kinds of magnesium-iron silicates have been studied in the laboratory, providing an excellent opportunity to have a deeper insight on the nature of the oxygen-rich cosmic dust grains.

2) Silicon carbide is the main component of the dust shells around carbon stars. However, a large number of carbon stars display unidentified features that have not been reproduced yet by modelling techniques. The recent studies of dust grains of astrophysical interest help us to investigate the origin of such features in more detail than it was possible in the previous years.

3) Many carbon stars with optically thin envelopes show a large far-infrared flux excess, usually ascribed to the presence of a cool detached dust shell. The nature of these detached shells is a controversial matter. It has been suggested that either they are a remnant of the star's former O-rich phase, or they have been produced during a (recent) past episode of higher (than the current) mass loss rate, when the star was already carbon-rich.

In agreement with previous results, we found that, in the circumstellar environments of oxygen-rich stars, silicate grains with olivine stoichiometry are more likely to be present than those with pyroxene stoichiometry, which, instead, might be responsible for some of the unknown features observed in the mid-IR spectra of carbon stars. Small percentages of carbon-rich grains in the circumstellar environments of oxygen-rich stars are not excluded.

Several causes can be invoked to explain the large flux observed at longer wavelengths in carbon stars. In this sense, the problem of the far-IR flux excess of carbon stars does not have a unique solution. If the large flux observed at longer wavelengths is produced by phenomena of non-constant mass loss, the derived time scale for such phenomena is of $10^3 - 10^4$ years.

Thesis-related Publications: A&A 301, 501; A&A (1997, in press); Ap&SS (submitted)

Upcoming Meetings

189th Meeting of the AAS
January 12 - 16, 1997 – Toronto, Canada
Contact: http://www.aas.org/meetings/meetings.html

Fundamental Stellar Properties: The Interaction Between Observation and Theory (IAU Symp. 189)
January 13 - 17, 1997 – Sydney, Australia
Contact: J. Davis (davis@physics.usyd.edu.au)

Herbig-Haro Flows and the Birth of Low Mass Stars (IAU Symp. 182)
January 20 - 24, 1997 – Chamonix, France
Contact: iau182@gag.observ-gr.fr or http://gag.observ-gr.fr/meetings/iau182

Intl. School of Space Chemistry (NATO Adv. Study Inst.)
March 10 - 20, 1997 – Erice, Sicily
Contact: J.M. Greenberg (mayo@rulhl1.LeidenUniv.nl)

Brown Dwarfs and Extrasolar Planets
March 17 - 20, 1997 – Tenerife, Spain
Contact: bdexp@iac.es or http://www.iac.es/bdexp/bdexp.html

Dust and Molecules in Evolved Stars
March 24 - 27, 1997 – Manchester, UK
Contact: I. Cherchneff (imc@ast.ma.umist.sc.uk)

New Perspectives on Solar Prominences
April 28 - May 4, 1997 – Aussois, France
Contact: D. Rust (david.rust@jhuapl.edu)

AAS Solar Physics Division
June 26 - July 1, 1997 – Bozeman, Montana USA
Contact: L. Acton (acton@physics.montana.edu)

ISO's View on Stellar Evolution
July 1 - 4, 1997 – Noordwijkerhout, the Netherlands
Contact: isostar@astro.uva.nl or http://www.astro.uva.nl/isostar/

38th Herstmonceux Conf.: The Stellar Initial Mass Function
July 14 - 18, 1997 – Cambridge, UK
Contact: D. Howell (debbie@ast.cam.ac.uk)

10th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun
July 15 - 19, 1997 – Cambridge, Mass. USA
Contact: cs10@cfa.harvard.edu or http://cfa-www.harvard.edu/CS10/

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

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