COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 6 — March 1996 Editor: Steve Skinner (coolnews@jila.colorado.edu)

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From the Editor

For those of you who were typographically-challenged by the long Web-page URL given in the February issue, a new shorter URL is now available. The long version should still work, but the preferred shorter URL is:

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

I would like to encourage all readers to take advantage of the *Announcements* capability of the newsletter. If you have announcements of upcoming meetings, summaries of recent meetings, job postings, reviews of new books, or other information of general interest to the community, please send them in and they will receive wide distribution.

Mechanical Heating Levels in Ultra-fast Rotating Dwarfs

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Using available observational data we have estimated the total radiative output from the chromospheric/coronal plasma as a result of magnetic heating for several F, G, K & M dwarfs. When tabulated as a function of the bolometric flux, a clear 'levelling-off/saturation' exists for the faster rotators as found previously when using single spectral lines. However, using recent chromospheric radiative transfer model calculations it is shown that this 'saturation' can be due to a significantly larger fraction of the losses being radiated by Hydrogen in the ultraviolet/optical/infrared continuum regions. The implication being that these ultra-fast rotators have a high density chromosphere, plus a high temperature minimum, although additional chromospheric model calculations are required which include better molecular line opacities plus and an extension of the models for stars with higher effective temperatures.

Accepted by A&A

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The Intrinsic Ly α to H α ratio in M Dwarf Stars

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Using Ly α line profiles generated from a grid of M dwarf model atmospheres we calculate the attenuation factors due to the interstellar medium as a function of hydrogen column density. Then using selected model atmospheres, attenuation factors were calculated for those M dwarfs with available Ly α observations. The prime motivation in this work has been to look afresh at the intrinsic Ly α to H α ratio, an important constraint in the radiative transfer modelling of M dwarfs. For those active dMe stars where both lines were observed, the intrinsic ratio is $\sim 4-6$ (with $\sim 50\%$ variation). The major uncertainly in this work has been the interstellar hydrogen column density, emphasizing the need for further work in this area and in particular an accurate model of its variation in all directions.

Accepted by A&A

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Fluorine Production in Intermediate-mass Stars

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The ^{19}F production during the first dozen thermal pulses of AGB stars with masses M and metallicities Z ($M = 3\,\mathrm{M}_\odot$, $Z = 0.02$), ($M = 6\,\mathrm{M}_\odot$, $Z = 0.02$) and ($M = 3\,\mathrm{M}_\odot$, $Z = 0.001$) is investigated on grounds of detailed stellar models and of revised rates for $^{15}\mathrm{N}\,(\alpha\,,\gamma)\,^{19}\mathrm{F}$ and $^{18}\mathrm{O}(\alpha,\gamma)^{22}\mathrm{Ne}$. These calculations confirm an early expectation that ^{19}F *is* produced in AGB thermal pulses. They also enlarge substantially these previous results by showing that the variations of the level of ^{19}F production during the evolution is very sensitive to the maximum temperature reached at the base of the pulse. These variations are analyzed in detail, and are shown to result from a subtle balance between different nuclear effects (mainly ^{19}F production or destruction in a pulse, and ^{15}N synthesis during the interpulse), possibly superimposed on dilution effects in more or less extended pulse convective tongues.

Our calculations, as most others, do not predict the third dredge-up self-consistently. When parametrized, it appears that our models of intermediate-mass AGB stars are able to account only for the lowest ^{19}F overabundances observed

in solar-metallicity MS, S and C stars. That conclusion is expected to hold true for low-mass stars when fluorine production results from secondary ^{13}C only. Massive AGB stars, on the other hand, are not expected to build up large surface F abundances. Therefore, the large fluorine overabundance reported for the super Li-rich star WZ Cas (where hot bottom burning is supposed to be operating) remains unexplained so far. Our results for the ($3\,M_\odot$, $Z = 0.001$) star indicate that fluorine surface overabundances can also be expected in low-metallicity stars provided that third dredge-ups occur after the early cool pulses. The relative increase in the surface ^{19}F/^{12}C ratio is, however, lower in the low-metallicity than in the solar-metallicity star. No observations are reported yet for these stars, and are urgently called for.

Accepted by A&A

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or via anonnymous ftp through ftp obsftp.unige.ch, cd /pub/mowlavi, get fluor.ps.gz

or on ftp://obsftp.unige.ch/pub/mowlavi, *file* fluor.ps.gz

HDE 233517: Lithium and Excess Infrared Emission in Giant Stars

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Recent studies have identified a small class of moderately rapidly rotating, chromospherically active, single giants, some of which are lithium rich. We present evidence suggesting the peculiar K-type star HDE 233517 is one such object. Previously, HDE 233517 has been suggested to be a young star, consistent with its large far-infrared excess and our log ϵ(Li)$\sim$3.3. However, our high-resolution spectroscopic observations show it is likely a single, post-main-sequence K2 giant with vsini=15 km/s and modest Ca II H and K emission. The giant status of HDE 233517 is determined directly from luminosity-sensitive line ratios and lack of significant line wings, and is further supported by a large radial velocity (46.5 km/s), small proper motion, and the presence of interstellar absorption features. Interpretation of the data in the context of a recent mass outflow model for giant stars proposed by de la Reza et al. (1996), indicates that HDE 233517 has the largest mass-loss rate, 3 x 10^{-7} $M_\odot$/yr, of any known luminosity class III giant. We suggest that the processes causing rapid rotation, large lithium abundance, and infrared excess are triggered at the base of the giant branch when the convection zone reaches the rapidly rotating core of low-mass stars.

Accepted by ApJ Letters

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Limits to Mass Outflows from Late-Type Dwarf Stars

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We show that the mass-loss rates of active late-type dwarf stars must be significantly lower than recent estimates of up to $\sim 5 \times 10^{-10}$ $M_\odot$ yr^{-1}, 4 orders of magnitude higher than that of the Sun. First, we present aperture synthesis observations at 3.5 mm of the dMe flare stars YZ CMi and AD Leo, during which neither star was detected at an upper limit of 10 mJy. Although compatible with the tentative detection of YZ CMi at 1.1 mm reported by Mullan et al. (1992) if the millimeter emission originates from a $\sim 10^4$ K, 300 km s^{-1} wind with $\dot{M} \approx 5 \times 10^{-10}$ $M_\odot$ yr^{-1}, we show that such a wind would completely absorb the observed radiation from coronal radio flares originating from close to the stellar surface. From this contradiction, we show that the mass-loss rate of any $\sim 10^4$ K wind with velocity similar to the solar wind (300–600 kms^{-1}) must be less than $\sim 10^{-13}$ $M_\odot$ yr^{-1}, more than 3 orders of magnitude below that inferred by Mullan et al. (1992). The upper limit to a $\sim 10^6$ K wind, similar in temperature to the solar wind, is $\dot{M} \approx 10^{-12}$ $M_\odot$ yr^{-1}, an order of magnitude below the lower limit predicted theoretically by Badalyan & Livshits (1992). Our arguments apply to all classes of stars which display coronal radio flares, implying that the mass-loss rate of active late-type dwarf stars from any $\sim 10^4$ K or $\sim 10^6$ K winds with velocities similar to the solar wind cannot be more than about one or two orders of magnitude, respectively, higher than the solar mass-loss rate of $\sim 3 \times 10^{-14}$ $M_\odot$ yr^{-1}. We show that coronal mass ejections also are unlikely to explain the reported mm emission

from dMe flare stars, and that the time-averaged mass-loss rate from such events can be no higher than in the case of a steady spherically–symmetric stellar wind.

Accepted by ApJL

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A Relationship Between Mean Rotation Period in Lower Main-Sequence Stars and Its Observed Range

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Chromospheric Ca II H and K fluxes have been measured in a sample of ~ 100 stars on or near the lower main sequence at Mount Wilson Observatory. Observations were made several times a week and span more than ten years. Within an observing season, many stars show periodic variations due to rotation. Thirty-six of the stars have highly-significant periods in at least five seasons. We compute the range in the observed period, ΔP, and suggest that it is a measure of, and a lower limit to, the surface differential rotation (SDR).

Several physical and selection effects can affect the measured ΔP value. An analysis of the cumulative variance distribution at various time scales, however, demonstrates that Ca II variations due to active region growth and decay are of longer period and smaller amplitude than those due to rotation. We argue that other effects (e.g., multiple active regions, latitude bands) are either small, or primarily act to reduce the measured ΔP relative to its true value.

Including results for the Sun, we find that ΔP depends on the mean seasonal rotation period $\langle P \rangle$, such that $\Delta P \propto \langle P \rangle^{1.3 \pm 0.1}$, independent of mass. We briefly discuss this in the context of dynamo models, and other observations of surface differential rotation and active region structure.

Accepted by ApJ, scheduled for 20 July 1996 issue

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A Close Look at the Coronal Density of Procyon

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We derive the coronal density of the nearby star Procyon, using an observation with the short and medium wavelength spectrometers on board the Extreme Ultraviolet Explorer Satellite (EUVE). Specifically, we have identified density sensitive ratios in lines due to iron in ionization stages Fe X to Fe XIV, which have been detected in our EUVE spectra. We present these observations and analyse these line ratios, paying careful attention to line blends or contamination from other EUV lines. We show that all the available density sensitive iron line diagnostics are consistent with the interpretation that the overall coronal output of Procyon is dominated by regions with a coronal density very much resembling densities typically found in active regions on the Sun. We estimate that the corona of Procyon is dominated by material at a temperature $T_{cor} \sim 10^{6.2}$ K, with no significant amount of material above $T \sim 10^{6.8}$ K; the characteristic density is $n_e \sim 3 \times 10^9$ cm^{-3}; the emission measure is $EM \sim 4.5 \times 10^{50}$ cm^{-3}. We infer a (visible) volume of $V_{tot} \sim 5 \times 10^{31}$ cm^3; assuming the X-ray emission to arise from plasma magnetically confined in loops, we deduce that such loops have an average height of $h \sim 2 \times 10^9$ cm and cover about 20 percent of the stellar surface. Because of the high coronal density and the lack of emission measure substantially below $T \sim 10^6$ K, we also conclude that it is unlikely that there exists a cooler, acoustically-heated sub-corona. Accepted by ApJ

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Rotation Periods of Selected Members of the α Persei Cluster

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We present the results of a photometric monitoring programme of 9 G-K dwarf members of the young open cluster surrounding α Persei.

The aim of this programme was to measure the axial rotation periods of 5 rapid rotators ($v \sin i > 50$ km s^{-1}) and 4 slow rotators ($v \sin i \leq 10$ km s^{-1}) to further our study of the rotation distribution of the cluster's low mass population. We successfully measured accurate periods for all of the 5 rapid rotators, most of which exhibited significant rotational modulation.

In contrast the slow rotators exhibited light-curve amplitudes below the threshold of photometric detectability. We applied a formal statistical analysis to our data and found strong evidence for variability (ΔV $\sim$ 0.03 mag.) in only one of the slow rotating targets.

Submitted to MNRAS

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Coronal Activity in the Coma Berenices Open Cluster

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We present ROSAT PSPC observations of the $\sim$ 500 Myr old Coma Berenices cluster. The X-ray survey in Coma consists of a) a raster scan of short duration PSPC pointings, b) ROSAT All-Sky Survey data, and c) a 16 ksec deep PSPC pointing. The raster scan and the survey data were merged together covering an area of about 36 square degrees, while the deep pointing was analyzed separately. No major differences were found between the two datasets.

Our ROSAT observations indicate that Coma is much more similar in its X-ray properties to the coeval Hyades than to the also coeval Praesepe cluster. As in the Hyades, almost all late-F and G stars were detected, also showing a comparable range in X-ray luminosity. X-ray luminosity distribution functions (XLDFs) for solar-type members are in close agreement with those of the Hyades, confirming that the majority of Praesepe's members are less luminous than what one would expect for stars of their age.

The Coma Berenices cluster is known for its apparent deficit of low mass stars of spectral type K and later. We present 12 new possible low-mass Coma candidates, identified through this X-ray survey.

Accepted by A&A

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The Wind Outflow of ζ Aur: a Model Revision Using *HST* Spectra

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Using high-resolution spectra taken with the *GHRS* aboard the *Hubble Space Telescope* and with the *IUE* satellite, we reconsider the wind model of ζ Aurigae (K4 Ib + B5 V). The high quality of the *HST* data permits a critical test of the simplifying assumptions previously used to analyze *IUE* spectra. We find the line profiles observed with the *GHRS* show a complex structure which seems to be inconsistent with the model of a spherically expanding envelope.

With detailed line profile calculations we show that these observations are essentially compatible with a spherical wind outflow in a global sense. However, the distribution of ions must be corrected for ionization effects induced by the B star UV radiation field. We are able to retain the 'classical' model by introducing some ad hoc modifications

and confirm the earlier wind analyses of ζ Aur. We obtain a mass loss rate of $5 \times 10^{-9}\,\mathrm{M_\odot\,yr^{-1}}$ and a terminal wind velocity of $70\,\mathrm{km\,s^{-1}}$. The deduced line broadening velocities clearly decrease with the radial position. The microturbulence is about $20\,\mathrm{km\,s^{-1}}$ in the inner envelope ($r \geq 1.2\,\mathrm{R_{sg}}$) and reaches a minimum of $\sim 8\,\mathrm{km\,s^{-1}}$ at large distances ($r \geq 25\,\mathrm{R_{sg}}$).

To demonstrate some important effects and to support the reliability of our results we present a series of model calculations which show the sensitivity of the line formation to the large-scale wind properties. The emission components of strong resonance lines are formed in a region extending up to 50 K star radii and are only slightly dependent upon the global wind geometry. We show that resonance scattering considerably influences the line formation and may distort all analyses that assume pure absorption.

Accepted by ApJ

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ROSAT Observation of a Giant X-ray Flare on Algol: Evidence for Abundance Variations?

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Algol was observed with the *PSPC* detector onboard *ROSAT* in August 1992 for 2.4 binary orbits. In the middle of the observation a giant X-ray flare occurred, lasting about half the orbital period. Spectral fits with a one-temperature thermal model indicate significant variations of the metal abundance Z over the flare. The abundance increases from $Z \simeq 0.2$ to 0.8 during the rise phase, and decreases to $Z \simeq 0.4$ during the decay. Thus, the abundance variation is similar to that recently observed by *ASCA* for a flare on AB Dor. Two-temperature models with the abundance fixed at $Z = 0.3$ and 1.0, respectively, cannot fit all phases of the flare. During the early flare rise, the plasma temperature and density are maximal ($T \simeq 10^8\,K$, $n_e \simeq 5 \cdot 10^{11}\,cm^{-3}$), and there is evidence for a large temperature gradient. During the flare decay, an N_H increase by a factor 2 may be present. The flare has a thermal energy of $7 \cdot 10^{36} erg$, a peak luminosity of $2 \cdot 10^{32} erg/s$ and is classified as two-ribbon. Because of re-heating the flare plasma does not cool quasistatically; nevertheless, applying the quasistatic cooling method, a loop length of $5 \cdot 10^{11}\,cm$ corresponding to a height of $0.65\,R_K$ is derived. From the unique sample of three major flares detected in six X-ray observations, the frequency of large X-ray flares on Algol is determined as $0.6/P_{orb}$.

Accepted by A&A

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Dynamics of the Chromospheric Network; Mobility, Dispersal, and Diffusion Coefficients.

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Understanding the physics behind the dispersal of photospheric magnetic flux is crucial to studies of magnetoconvection, dynamos, and stellar atmospheric activity. The rate of flux dispersal is often quantified by a diffusion coefficient, D. Published values of D differ by more than a factor of two, which is more than the uncertainties allow. We propose that the discrepancies between the published values for D are the result of a correlation between the mobility and flux content of concentrations of magnetic flux. This conclusion is based on measurements of displacement velocities of Ca II K mottles using an uninterrupted 2–day sequence of filtergrams obtained at the South Pole near cycle minimum. We transform the Ca II K intensity to an equivalent magnetic flux density through a power–law relationship defined by a comparison with a nearly simultaneously observed magnetogram. One result is that wherever the network is clearly defined in the filtergrams, the displacement vectors of the mottles are preferentially aligned with the network, suggesting that network–aligned motions are more important to field dispersal than deformation of the network pattern by cell evolution. The rms value of the inferred velocities, $R = \langle|\vec{v}|^2\rangle^{\frac{1}{2}}$, decreases with increasing flux, Φ, contained in the mottles, from $R \approx 240$ m s^{-1} down to ≈ 140 m s^{-1}. The value of $R(\Phi)$ appears to be independent of the flux surrounding the concentration, to the extreme that it does not matter whether the concentration is in a plage or in the network. The determination of a proper effective diffusion coefficient requires that the function $R(\Phi)$ is weighted by the number density $n(\Phi)$ of mottles containing a total flux Φ. We find that $n(\Phi)$ decreases exponentially with Φ, and propose a model of continual random splitting and merging of concentrations of flux to explain this dependence. Traditional methods used to measure D tend to be biased towards the larger, more sluggish flux concentrations. Such methods neglect or underestimate the significant effects of the relatively large number of the more mobile smaller concentrations. We argue that the effective diffusion coefficient for the dispersal of photospheric magnetic flux is roughly $600\,\mathrm{km}^2\,\mathrm{s}^{-1}$.

Submitted to ApJ

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Upcoming Meetings

Solar and Heliospheric Physics at EGS96

On behalf of the Programme Committee of the European Geophysical Society (EGS) we cordially invite you to participate in the forthcoming XXI General Assembly of EGS to be held in The Hague, The Netherlands, 6-10 May 1996. We draw your attention to the following Solar and Heliospheric sessions:

ST1 25th EGS Anniversary Review Session on Solar Terrestrial Sciences [Convener - R.A. Harrison][Duration 0.5 day]

ST5 Open Session on Solar and Heliospheric Physics [Conveners - B.H.Foing, R. Marsden][Duration 1 d]

ST6 The Solar terrestrial Science Programme and ISTP Missions
-ST6a Workshop on Results from Solar Terrestrial Science Prog. [Convener - R.A. Harrison][Duration 1 d]
-St6b Interprogramme data exchange in the ISTP Missions [Conveners - G. Brueckner, H.Opgenoorth][Dur. 0.5 d]

ST7 The High Latitude heliosphere [Convener - R. Marsden][Duration 1 d]

ST8 Future Prospects in Solar and Heliospheric Observation [Total 1.5 d]
-ST8a Monitoring the Sun and Heliosphere in Stereo [Conveners - V. Bothmer, B.H. Foing][Duration 0.75 d]
-ST8b Anticipating the next Solar and Heliospheric Missions [Conveners - E. Marsh, A. Roux][Duration 0.75 d]

ST9 Collisionless Shocks and Plasma Waves in the Heliosphere [Conveners - W. Macek, D. Burgess][Duration 1 d]

ST10 Solar-Terrestrial Events and their effects on Ionosphere/Atmosphere [Conveners - J. Lastovicka, S. Kirkwood] [Duration 1 d]

We look forward meeting you at EGS 96 in The Hague.

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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 .`