COOLNEWS

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Stellar Abstracts

Bipolar Pre-Planetary Nebulae: Hydrodynamics of Dusty Winds in Binary Systems. I. Formation of Accretion Disks.

Nikos Mastrodemos[1] and Mark Morris[1]

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Mass-losing giant stars and objects in transition to planetary nebulae often display a bipolar symmetry in their outflowing circumstellar envelopes. Here we initiate a detailed study of the hypothesis that the observational characteristics of asymmetric and bipolar preplanetary nebulae result from the influence of a detached binary companion upon the initially spherical wind of the mass-losing star, using 3-dimensional smoothed particle hydrodynamics models. In this first work we describe the dusty wind models and the numerical procedure employed, and we address the issue of wind accretion and the formation of accretion disks about the binary companion to the mass-losing giant, as a function of wind velocity and binary separation. In all of our models, we find that permanent, stable accretion disks of various sizes form around the binary companion. The disks are geometrically thin and their equilibrium structure has elliptical streamlines with a range of eccentricities. Our result also indicates that such disks may be susceptible to tilt or warping instabilities. We also find that wind accretion in such binaries is stable, displaying no evidence for any type of flip-flop instability.

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M Subdwarf Secondaries: A Test of the Metallicity Scale

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We present spectra of three M subdwarfs which are common proper motion companions to F or G subdwarfs of known metallicity. The assumption that the companions have the same composition allows us to test the Gizis (1997, AJ, 113, 806) M subdwarf classification system and its correspondence to metallicity. The results are in excellent

agreement with the Gizis (1997) scale, thereby showing that the Allard & Hauschildt (1995, ApJ, 445, 433) extended model atmospheres agree well in the 6200 – 7400Å region for cool metal-poor stars. We also show that the results are consistent with the main sequences of globular clusters using the Reid (1997, AJ, 114, 161) distance scale.

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X-ray Spectroscopy of the Active Giant β Ceti: the SAX LECS View

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We present an X-ray observation of the active giant β Ceti performed with the Low Energy Concentrator Spectrometer (LECS) on-board the SAX satellite. The resulting X-ray spectrum is well fitted by an optically-thin plasma model with two discrete temperatures, and the inferred coronal metallicity is compatible both with the abundances derived from a re-analysis of the ASCA SIS spectrum of the same object, adopting the same plasma emission code (MEKAL), and with accurate photospheric abundances recently reported in the literature. The remarkable similarity between the X-ray spectrum of β Ceti and the one of the active binary Capella, also observed by SAX, rises again the issue of how some putative He-burning clump giants, like β Ceti, manage to retain (or regain) a relatively high X-ray activity level. Some implications of the new Hipparcos parallaxes, relevant for the coronal properties of β Ceti and the Hyades giants, are also discussed.

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A Multi-Wavelength Campaign on γ Cas. I. The Case for Surface X-Ray Flaring

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We have obtained simultaneous *RXTE*/PCA and HST/GHRS light curves for the B0.5e star γ Cas in order to compare its X-ray and ultraviolet continuum flux behaviors. The GHRS dataset consisted of a nearly continuous time sequence of UV spectra covering a 21+ hour interval. Each 40 Å spectrum was centered on the Si IV $\lambda\lambda$1394–1403 lines and registered 8100 counts in each 1 s exposure. Combining spectra and integrating over >100 continuum pixels allowed us to define a UV continuum light curve binned to 1 minute with an S/N ratio of a few thousand pix^{-1}. We found that the light curve exhibited variations over a time comparable to the rotation period of the star, showing two broad minima 10 hours apart and having depths of 0.8% and 1.8%. The long-term trends in the UV are anti-correlated with the X-ray fluxes, with the X-rays exhibiting increases of ~10% and ~40% during times of UV flux minima. The stability of the long-term X-ray variations on γ Cas has been confirmed by phasing our March data with contemporaneous *ASCA* data. This gives an X-ray modulation period very close to an estimate of 1.123 days we obtain from phasing the *GHRS* continuum flux curve with an *IUE* light curve from two months earler. We take this as an estimate of the star's rotational period.

The X-ray emission from γ Cas consists of two components. The first is a slowly varying "basal" flux representing the minimum level seen during any given phase. Superimposed on this are rapid fluctuations ("shots") which have lifetimes ranging from < 10 s to ≥10 minutes. The character of these components varies from orbit to orbit, indicating that the emissions are not produced in a "stationary," truly chaotic environment. Moreover, both the number and amplitude of the shots increase as the UV flux decreases. The shot profiles are typically symmetric and can have decay times of a few seconds or less. The shots also have a slightly harder flux distribution than the basal component,

suggesting that the two emission regions are not cospatial. The X-ray spectrum indicates a quasi-temperature of $\sim 10^8$ K, in agreement with earlier studies.

We present a picture in which the observed UV continuum variations result from the presence of magnetically-generated structures on or over the star's surface. These features are probably associated with both the basal and shot component, which we model as flare-like events arising within the photosphere. The energies and luminosities of the flares are very strong. For example, the luminosities of even the weakest events in our sample are comparable in strength to the most luminous flares found on cool active stars. Using simple plasma cooling arguments, we find that the source region for the shots has a size scale of $\leq 10^4$ km and densities of $\sim 10^{14}$ cm^{-3}. Typically, only a small fraction of the energy is radiated during a shot event; the remainder fills a surrounding confined volume, perhaps a loop. The heating resulting from many such shots powers basal emission. The loops have a characteristic density of $\leq 10^{11}$ cm^{-3} and scale length of $\geq 0.1 R_*$. This interpretation raises several theoretical questions, such as: how can complex, dymamic fields exist on a star which does not have a convective envelope, and can how flares occur in a plasma with T $\sim 10^8$ K and $N_e \sim 10^{14}$ cm^{-3}?

These results suggest that γ Cas is a member of an arguably new group of hot stars which flare continuously. This group may represent an extension of the Si- and He-anomalous Bp stars to high values of rotation.

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Editor's Note: The above abstract appeared in The Hot Star Newsletter (No. 32 - Aug. 1997) and is being reprinted here since it may be of interest to cool star researchers studying magnetic surface activity.

Near-infrared Narrow-band Photometry of M–giant and Mira Stars: Models Meet Observations

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From near-infrared, narrow-band photometry of 256 oxygen-rich Mira variables we obtain evidence about the loops that these stars follow in colour–colour diagrams. We also find a phase lag between indices related to molecular band-strength of titanium oxide and vanadium oxide. We compute colours for normal M–giants and Miras using hydrostatic and hydrodynamic model atmospheres and very extensive up-to-date line lists. Normal M–giants colours are well reproduced, reaching a high quantitative agreement with observations for spectral types earlier than M7. The out-of-phase variations of the various spectral features of Miras are also acceptably reproduced, despite limitations in the modelling. This enables us to confirm that the phase lag phenomenon results from the propagation of perturbations in the extended atmosphere. It opens new perspectives in the spectral modelling of Miras.

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Multiwavelength Optical Observations of Chromospherically Active Binary Systems. II. EZ Pegasi

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The star EZ Peg, long ago classified as cataclysmic variable, has been shown to be a chromospherically active binary system of the RS CVn-type.

In this paper we have analysed, using the spectral subtraction technique, simultaneous spectroscopic observations of the Hα, Hβ, Na I D_1 and D_2, He I D_3, Mg I b triplet, Ca II H & K, and Ca II infrared triplet lines.

We have found that the hot component is the active star of the system, showing strong emission in the Hα, Ca II H

& K, Hϵ, and Ca II IRT lines, and a strong filling-in of the Hβ line, however the Na I D_1 and D_2 and Mg I b triplet lines not present filled-in. The He I D_3 could present a total filling-in due to microflaring.

The observed variations (in different epochs and with the orbital phase) of the different activity indicators, formed at different height in the chromosphere, are correlated.

Very broad wings have been found in the subtracted profiles of Hα and Ca II IRT λ8498 and λ8662 lines. These profiles are well matched using a two-components Gaussian fit (narrow and broad) and the broad component could be interpreted as arising from microflaring.

The higher luminosity class of the hot component, that our spectra seem to indicate, could explain why the hot component is the active star of the system.

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APMPM J1523-0245: A New High-Proper Motion Cool Subdwarf

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We present the discovery of a new high proper motion star, APMPM J1523-0245. This object has a proper motion of 0.6 arcsec yr^{-1} and has an R magnitude of 18. Spectroscopy indicates that it is a cool metal-poor star with spectral type sdM5.5. APMPM J1523-0245 is only the sixth known subdwarf later than type sdM5.0.

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Basal Heating in Main-Sequence Stars and Giants: Results from Monochromatic Acoustic Wave Models

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We calculate time-dependent models of acoustically heated chromospheres for main-sequence stars between spectral type F0 V and M0 V and for two giants of spectral type K0 III and K5 III assuming monochromatic waves. The hydrodynamic equations are solved together with the radiative transfer and statistical equilibrium equations to investigate the propagation of acoustic waves into the chromospheric regions. The emergent radiation in Mg II h+k and Ca II H+K are calculated and compared with observations. We find good agreement, over nearly two orders of magnitude, between the time-averaged emission in these lines and the observed basal flux emission, which had been suspected to be due to nonmagnetic (i.e., acoustic) heating operating in all late-type stars. The height dependence of the acoustic energy flux can be explained by the limiting strength property of the acoustic shocks and is consistent with that found in models of quiet solar regions. We also confirm the validity of the Ayres' scaling law, which has originally been derived for semiempirical chromosphere models and is thus independent of assumptions about the chromospheric heating mechanism. Our results strongly support the idea that the "basal heating" of chromospheres of late-type stars as revealed by the frequency-integrated Mg II and Ca II line emission is fully attributable to the dissipation of acoustic wave energy.

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Absolute Dimensions of Eclipsing Binaries. XXII. The Unevolved F-type System HS Hydrae

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We have redetermined the masses of the unevolved F-type eclipsing binary HS Hya ($P = 1.57$ days) from 70 observations with the CfA digital speedometers, combined with other observations from the literature. Analysis of our radial velocities determined with a two-dimensional cross-correlation technique shows the presence of a third star in the system, which we find to be most likely an M0 dwarf with a mass of ~ 0.5 M$_\odot$ in a 190-day orbit of small eccentricity and apparently co-planar with the eclipsing system. We also reanalyze an earlier set of light curves in the *uvby* system, using modern analysis techniques and combining all available spectroscopic and photometric data in the analysis. The resulting masses for the eclipsing stars are $M_{\rm A} = 1.255 \pm 0.008$ M$_\odot$ and $M_{\rm B} = 1.219 \pm 0.007$ M$_\odot$, ~ 6% smaller and ~ 6 times more accurate than previous values. The radii are $R_{\rm A} = 1.275 \pm 0.007$ R$_\odot$ and $R_{\rm B} = 1.216 \pm 0.007$ R$_\odot$, and the effective temperatures $T_{\rm A} = 6500 \pm 50$ K, $T_{\rm B} = 6400 \pm 50$ K; further properties of the stars are given in Table 7. Current stellar evolution models for the observed metallicity (slightly below solar) match the observed properties of both stars in HS Hya very well for a single, but strongly model-dependent age of ~ 1.0 Gyr. A precise spectroscopic determination of [Fe/H] for HS Hya is needed to further refine comparison with theoretical models.

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Low-mass Binaries in the Hyades - A Scarcity of Brown Dwarfs

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We have obtained *HST* Planetary Camera observations of a total of fifty-three low-mass ($M < 0.3 M_\odot$) members of the Hyades cluster. Nine of these stars are resolved as binaries, with separations between 0.1 and 3.1 arcseconds, while a further three are probably equal-mass systems at smaller separations. Allowing for observational selection effects, this corresponds to an observed binary fraction of 11.3 ± 4.6% for systems with separations in the range 14 to 825 a.u., consistent with observations of solar neighbourhood M-dwarfs. The mass-ratio distribution is only consistent marginally with the secondary stars being drawn from a $\Psi(M) \propto M^{-1}$ mass function, with three equal-mass systems amongst the six binaries with observed separations in the régime where our observations extend below the hydrogen-burning limit. Considering the entire sample, the absence of any brown dwarf companions amongst our sample makes it unlikely that the mass function of stellar/brown dwarf companions rises as steeply as M^{-1}. If the Hyades has an age of ~ 600 Myrs, our results are consistent only at the 2σ level with a flat (M^0) mass function.

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Lithium in Very Metal Poor Thick Disk Stars

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A search for lithium is performed on seven metal poor dwarfs with metallicities ranging from [Fe/H]=-1.5 down to [Fe/H]=-3.0 but showing disk–like kinematics. These stars belong to the metal poor tail of the Galactic thick disk and they may be also the result of an accretion event (Beers and Sommer-Larsen 1995). The Li 6707.8 Å line is present in all the seven dwarfs. The weighted average of the Li abundance for the stars is A(Li)=2.20 ±0.06 and is consistent within the errors with the *plateau* Li abundance of A(Li)=2.24± 0.012 found in genuine halo stars in

the same range of metallicities (Bonifacio & Molaro 1997). One of the stars, CS 22182-24, shows somewhat lower Li abundance (A(Li)=1.6±0.40) and is a candidate to being a Li-poor star. Whether this group of stars belongs to the oldest stars in the disk or to the old population of an external galaxy accreted by the Milky Way, the present observations provide support for the universality of a pre-Galactic Li abundance as is observed in the Galactic halo stars.

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The Stability of Late-type Stars Close to the Eddington Limit

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The opacity-modified Eddington limit has been computed for hydrogen-deficient model atmospheres. The R Coronae Borealis (R CrB) stars are found to be located strikingly close to the limit, which suggests that the unknown trigger mechanism for their visual declines of the stars are instabilities in connection with the stars encountering the Eddington limit in their evolution. It also points to a similarity between the eruptive behaviour of the R CrB stars and the Luminous Blue Variables (LBVs).

Super-Eddington luminosities in hydrostatic model atmospheres manifest themselves by the presence of gas pressure inversions. Such inversions are not an artifact of the assumption of hydrostatic equilibrium but can also be present in hydrodynamical model atmospheres. Only for very large mass loss rates hardly realized in supergiants will the inversions be removed. Instabilities may, however, still be present in such inversions, which is investigated for both H-rich and H-deficient late-type supergiant model atmospheres. Dynamically instabilities may occur in surface ionization zones, which might lead to ejections of gas. A local, non-adiabatic, linear stability analysis reveals that sound waves can be amplified due to the strong radiative forces. However, despite the super-Eddington luminosities, the efficiency of the radiative instabilities is fairly low compared to for early-type stars with growth rates of $10^{-5}\,s^{-1}$.

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Further Observations of Capella in the HeI λ 10830 Å Line: the Activity Cycle and Role of Binarity Effects

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High dispersion CCD spectra of the spectroscopic binary Capella in the infrared He I λ10830 Å line were obtained with the Shajn 2.6-m telescope of the Crimean Astrophysical Observatory during 1989 - 1994 over several orbital periods. An analysis of new data confirms our earlier conclusions: (i) the main (narrow) He I λ10830 Å line is formed in the outer atmosphere of the primary, cooler component, which is a G6 giant, as follows from the dependence of the radial velocity curves of the He I and photospheric lines on the orbital period, and (ii) the equivalent width of the He I line varies with the 104-day orbital period of Capella's binary. The mean level of the equivalent width values changes from year to year.

We show that the amplitude of variations of the equivalent width as a function of the orbital phase becomes lower when the mean level of the equivalent width is higher. The long-term variability of the helium absorption is reliably determined from uniform CCD observations in 1985 - 1994; this variability is associated with an activity cycle with a period of 6 years (this cycle is traced through all set of our data since 1980). During a season when the activity level of the Capella system was high, we were able for the first time to identify the fraction of the He I absorption formed in the chromosphere of the active, hotter F9 giant.

All these helium data together with the EUV results of Dupree & Brickhouse (1995) on the high-temperature Fe XX - Fe XXIII lines can be explained using a model with an enhanced magnetized stellar wind that originates from a

local region on the active F9 giant, and then forms a shock wave in the outer layers of the corona of the quiescent G6 giant.

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A Search for Variability in the Spectral Line Shapes of τ Boo: Does this Star Really Have a Planet?

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An analysis is made of the spectral line shapes of τ Bootis using high resolution (0.026 Å) and high signal-to-noise ($S/N \approx 400$) data in an effort to confirm the planet hypothesis for this star. Changes in the line shape are quantified using spectral line bisectors and line residuals. We detect no variations in either of these quantities above the level of the noise in the data. One spectral line, Fe I 6213 Å, does show a hint of sinusoidal variations in the bisector velocity span when phased to the radial velocity period of 3.3 days, but this is not seen in the bisectors for two other lines, nor in the line residuals. Comparisons of the data to the bisector and residual variations expected for nonradial pulsations indicate that we can exclude those sectoral nonradial modes having $m > 2$ and all sectoral modes with $k > 1$, where k is the ratio of the horizontal to vertical velocities for the pulsations. The lack of line shape variability and the 469 $\mathrm{m\,s^{-1}}$ radial velocity amplitude is still consistent with nonradial sectoral modes $m = 1$, and possibly $m = 2$, but with $k \approx 1$, which is at least 3 orders of magnitude less than the predicted value given the 3.3 day period of τ Bootis. Such low values of k can probably be excluded given the lack of photometric variations for this star. Although the measurements presented here do not prove, without any doubt, that τ Boo has a planetary companion, they do add significantly to the increasing body of evidence in favor of this hypothesis.

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On the Nature of the Radial Velocity Variability of Aldebaran: A Search for Spectral Line Bisector Variations

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The shape of the Ti I 6303.8 Å spectral line of Aldebaran as measured by the line bisector was investigated using high signal-to-noise, high resolution data. The goal of this study was to understand the nature of the 643-day period in the radial velocity for this star reported by Hatzes and Cochran. Variations in the line bisector with the radial velocity period would provide strong evidence in support of rotational modulation or stellar pulsations as the cause of the 643-day period. A lack of any bisector variability at this period would support the planet hypothesis.

Variations in the line asymmetries are found with a period of 49.93 days. These variations are uncorrelated with 643-day period found previously in the radial velocity measurements. It is demonstrated that this 50-day period is consistent with an $m = 4$ nonradial sectoral g-mode oscillation. The lack of spectral variability with the radial velocity period of 643 days may provide strong evidence in support of the hypothesis that this variability stems from the reflex motion of the central star due to a planetary companion having a mass of 11 Jupiter masses. However, this long-period variability may still be due to a low order ($m = 2$) pulsation mode since these would cause bisector variations less than the error measurement.

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Rotation and Chromospheric Activity in Field M Dwarfs

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We have obtained high resolution spectra for a volume-limited sample of 118 field M dwarfs. From these observations we derive projected rotational velocities and fluxes in the H_α and H_β lines. Eight stars are double-lined spectroscopic binaries with measured or probable periods short enough for rotation to be tidally synchronized with the orbit, and another 11 are visual binaries where we cannot yet separate the lines of the two stars. Of the remaining 99 stars, 24 have rotational velocities above our detection limit of ∼2 km/s, and some are quite fast rotators, including two with vsini ∼ 30 km/s and one with vsini ∼ 50 km/s. Given the small radii of M dwarfs these moderate rotation velocities correspond to rather short maximum rotation periods, of only 7-8 hours. These three stars are good candidates for Doppler imaging.

We find that rotation is strongly correlated with both spectral type and kinematic population: all stars with measurable rotation are later than M3.5, and all but one have kinematic properties typical of the young disk, or intermediate between the young disk and the the old disk. We interpret this correlation as evidence for a spin-down timescale that increases with decreasing mass. At the age of the old disk or halo, all stars earlier than M5-M6 (0.1-0.15$M_\odot$) have spun-down to below our detection limit, while at the age of the young disk this has only happened for stars earlier than M3.5. The one star with measurable rotation and a kinematics intermediate between old disk and population II has spectral type M6. It is probably an old star whose mass is low enough that it has retained significant rotation up to present, still consistently with longer spin-down times for lower mass stars. We observe, on the other hand, no conspicuous change in the $v\sin i$ distribution or activity pattern at the mass (M$\sim$ 0.35 $M_\odot$) below which stars remain fully convective down to the main sequence.

These new data are consistent with a saturated correlation between rotation and activity, similar to the one observed for younger or more massive stars: L_x/L_{bol} and L_{H_α}/L_{bol} both correlate with $v\sin i$ for $v\sin i \lesssim 4-5 km.s^{-1}$ and then saturate at respectively $10^{-2.5}$ and $10^{-3.5}$.

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The Effect of Photospheric Granulation on the Determination of the Lithium Abundance in Solar-type Stars

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I investigate non-LTE (non-local thermodynamic equilibrium) formation of the 670.6 nm LiI resonance doublet in the presence of convective surface inhomogeneities in solar-type stars. This doublet is widely used for lithium abundance determination in stars. It has been suggested that the presence of hot and cool elements in a stellar atmosphere due to convective heat transport might lead to an underestimate of lithium abundance by as much as a factor of 10 when the equivalent width of the doublet is analyzed in terms of a one-dimensional plane-parallel model atmosphere.

To explore this possibility, I solved the two-dimensional non-LTE radiative transfer equations for a sufficiently large lithium model atom in a hydrodynamic simulation snapshot of the solar granulation. This was done for different values of the lithium abundance ranging from $A_{\rm Li} = 0.0$ to 3.3.

In all cases the effects of the inhomogeneities in the atmosphere on lithium line strength is small, never amounting to more than 0.1 dex in the derived abundance. This is mainly for three reasons. First, due to the exponential decrease of density with height in the gravitationally stratified stellar atmosphere, radiation escapes mostly vertically with little horizontal exchange. Some lateral transfer does occur at the boundaries between hot and cold elements, but the effect of this exchange on the spatially averaged line strength cancels out. It leads to a smoothing over the surface rather than to a diminishing overall strength of the doublet. Secondly, the sharp drop in temperature over hot upwelling material, in contrast to the much shallower gradient over the dark intergranular lanes, causes the 670.6 nm doublet to be deeper and narrower in the first and broader in the latter. Consequently, the contrast of equivalent line width between profiles emerging over hot upflows and cold downflows is small. Finally, because of its small abundance the opacity scale in lithium ionizing continua is mostly set by H^- bound-free processes. Optical depth unity at the photoionization edges, therefore, follows the contours of electron temperature, moderating contrast in the ionizing radiation field.

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Solar Abstracts

Non-Maxwellian Redistribution in Solar Coronal Lyman Alpha Emission

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This paper presents theoretical models of Lyman alpha emission from solar coronal holes, taking into account various plasma kinetic effects which induce departures from Maxwellian velocity distributions. Such phenomena as suprathermal tails, strong temperature anisotropies, and skewed or double-peaked distributions have been observed in the solar wind, and UV spectroscopy is beginning to be able to detect their signatures in the corona. For resonantly-scattered lines like Lyman alpha most of the physics is contained in the frequency-dependent redistribution function. The dependence of this function on the local plasma parameters is presented analytically for four different non-Maxwellian distributions, and optically-thin line intensities are computed for a fiducial model of the fast solar wind.

Isotropic power-law "kappa" tails in the velocity distribution should be detectable between 2 and 5 Å from line center, but it is difficult to distinguish such profiles from a macroscopic superposition of several wind-regions with independent (but still Maxwellian) motions. Anisotropic bi-Maxwellian distributions affect line profiles via both their perpendicular components (at the 85–90% level) and their parallel components (at the 10–15% level). Skewness caused by a Chapman-Enskog expansion in the conductive heat flux is detectable as a unique non-Gaussian profile shape, but other types of collisionally-beamed or skewed distributions may not noticeably affect the emission lines.

Submitted to ApJ

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On the Determination of the Quiet–Sun Center–to–limb Variation in Ca II K Spectroheliograms

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We present a method for the determination of the center–to–limb variation (CLV) for Ca II K spectroheliograms. It is based on the calculation of intensity histograms for rings of constant area. Using a simple cutoff criterion in the cumulative histograms, we are able to derive CLVs of the quiet–Sun regardless of the solar activity level. Using an example from the literature, we show in which way different methods of normalization of the quiet–Sun CLV may affect the results.

Accepted by Solar Physics

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On Novel Methods to Determine Areas of Sunspots from Photoheliograms

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Two novel methods of measuring umbral and penumbral areas of sunspots and of complex sunspot groups are described. Both methods comprise the digitization of photoheliograms by a frame grabber and the computation of intensity histograms of selected areas of activity.
The first method, called 'cumulative histogram method', in principle determines the intensity boundaries umbra–penumbra and penumbra–photosphere from the intersections of linear fits into the corresponding parts of the cumulative histograms of sunspots. The second method, called 'maximum gradient method', marks image pixels of a given

intensity level ±2 units wide as a white isophote on a display. Interactive variation of this level makes it easy to visually select the contour line fitting the boundary penumbra-photosphere (or umbra-penumbra) best. At the same level usually the width of the contour line is smallest. In both cases the summation of the pixel numbers above the corresponding intensity levels yields the umbral and the total sunspot areas, respectively. Some limitations of the two methods are discussed.

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Fine Structure in Sunspots I. Sizes and Lifetimes of Umbral Dots

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The analysis of a 4 1/2 hour series of high resolution white light observations of the umbra in a medium-size sunspot (NOAA 7519, observed on 5 June 1993 at the Swedish Vacuum Solar Telescope, La Palma) is described. An automatic identification and tracking algorithm was applied to umbral dots (UDs) observed in a destretched movie of 360 frames. In total, 662 UDs were tracked and their filling factor, sizes, and lifetimes were measured. It was found that large (diameter $> 0.4''$) and long-lived (lifetime > 10 minutes) UDs appear mostly in regions with enhanced umbral diffuse background intensity. UDs do not have a "typical" size. Their number rapidly increases with decreasing diameter down to the resolution limit. Similarly, UDs do not have a "typical" lifetime, and their number rapidly increases with decreasing lifetime. UDs with lifetimes below 10 minutes represent about 2/3 of the population; the median lifetime is 5.9 minutes.

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Fine Structure in Sunspots II. Intensity Variations and Proper Motions of Umbral Dots

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Temporal intensity variations of umbral dots (UDs) and dark nuclei (DNs), and proper motions of UDs, were analyzed in a 4 1/2 hour time series of high resolution white light images of the umbra in a medium-size sunspot (NOAA 7519). The observations were made on 5 June 1993 at the Swedish Vacuum Solar Telescope, La Palma. An identification and tracking algorithm was applied to UDs observed in a destretched movie of 360 frames. In total, 662 UDs were tracked, and their intensities, positions, and proper motions were measured. Power spectra of temporal intensity variations of UDs and DNs were computed, and several typical periods were found. The histogram of time-averaged intensities of UDs has two maxima; the UDs belonging to the brighter part of the population are located mostly at or near the umbral-penumbral boundary. The number of UDs decreases with increasing magnitude of the proper motion velocity. Speeds of UDs are grouped at 100 and 400 m/s. The observed spatial distribution of UDs with different proper motion velocities is found to be in contradiction to the generally accepted idea of moving "peripheral" and stationary "central" UDs. Both "fast" and "slow" UDs are present in all parts of the umbra. Thus velocity does not appear to be a good criterion for separating UDs into "peripheral" and "central" ones.

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Active Regions Observed in Extreme Ultraviolet Light by the Coronal Diagnostic Spectrometer on SOHO

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We present observations of five active regions made by the Coronal Diagnostic Spectrometer (CDS) on the Solar and Heliospheric Observatory (SOHO). CDS observes the Sun in the extreme ultraviolet range 150-780Å. Examples of active region loops seen in spectral lines emitted at various temperatures are shown. Several classes of loops are identified: those that are seen in all temperatures up to 2×10^6 K; loops seen at 10^6 K but not reaching 1.6×10^6 K; those at temperatures $2 - 4 \times 10^5$ K and occasionally at 6×10^5 K but not reaching 10^6 K. An increasing loop size with temperature and the relationship between the cool and hot structures is discussed. CDS observations reveal the existence of loops and other unresolved structures in active regions, at temperatures between $1.5 - 4 \times 10^5$ K, which do not have counterparts in lines emitted above 8×10^5 K. Bright compact sources only seen in the transition region lines are investigated. These sources can have lifetimes of up to several days and are located in the vicinity of sunspots. We study the variability of active region sources on time scales from 30 seconds to several days. We find oscillatory behaviour of He I and O V line intensities in an active region on timescales of 5-10 minutes.

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Fe I Line Shifts in the Optical Spectrum of the Sun

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New improvements in the measurement of both the optical solar spectrum and laboratory wavelengths for lines of neutral iron are combined to extract central wavelength shifts for 1446 lines observed in the Sun. This provides the largest available database of accurate solar wavelengths useful as a reference for comparison with other solar-type stars. It is shown how the velocity shifts correlate with line strength, approaching a constant value, close to zero, for lines with equivalent widths larger than 200 mÅ.

Accepted by A&AS

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Ph.D. Thesis Abstract

Evolution and Variability of the R Coronae Borealis Stars

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Ph.D dissertation directed by: Bengt Gustafsson

Ph.D degree awarded: June 1997

The R Coronae Borealis (R CrB) stars are characterized by their severe hydrogen-deficiency and drastic visual variability. This thesis is devoted to both of these issues using theoretical, numerical and observational investigations.

A large sample of the stars has been analysed to determine their elemental abundances, which trace both their ancestry and the history of stellar nucleosynthesis. For this purpose, line-blanketed, hydrogen-deficient model atmospheres have been constructed. The peculiar compositions of the stars indicate that they are in fact born-again giants, for which two explanations have been proposed: either a merger of two white dwarfs or a final He-shell flash in a post-AGB star, which briefly re-inflates the star back to giant dimensions. According to their composition, the stars can be divided into a homogeneous majority group and a diverse minority, which might reflect two different evolutionary backgrounds or the effect of dust-gas separation. The atmospheres bear witness of H- and He-burning in different phases as well as *s*-processing, but the high Si/Fe and S/Fe ratios of in particular the minority remain unexplained. The inability of the models to reproduce the C I lines suggests that standard model atmospheres are far from adequate descriptions of supergiants such as the R CrB stars.

An analysis of Sakurai's object, which has likely recently experienced a final He-shell flash, reveals similarities with the R CrB stars as regards chemical composition. More spectacular, the star shows evidence of very rapid evolution and nucleosynthesis, most notably a decrease in the H abundance and an increase in the Li and *s*-element contents within only five months. The star represents an impressively fast case of stellar evolution very rarely encountered.

The variability of the stars with fadings of up to 8 magnitudes is unique and not yet explained. It is probably due to obscuration events of the stars by newly formed dust clouds. Possible instabilities due to large radiative forces in the stellar atmospheres, which could be the unknown trigger mechanism for the variability by ejecting condensible material, are searched for. A connection between such instabilities and the declines is supported by the proximity of the stars to the theoretical opacity-modified Eddington limit.

Key words: Stellar evolution, stellar abundances, stellar atmospheres, instabilities, R Coronae Borealis stars, post-AGB stars.

Thesis-related Publications: A&A 294, 763; A&A 318, 521; A&A 321, L17; A&A in press

Announcement

Availability of ESA-MUSICOS Spectrograph

Dear Colleagues:

A cross-dispersed spectrograph (ESA-MUSICOS) has been built at ESTEC and commissioned at the 2.5 m Isaac Newton Telescope at La Palma since April 1996. It is offered for use by the community. Spectrograph performance is as follows:

Resolution is 32,000 with the Tek detector 1Kx1K from INT. The data acquisition is standard and locally supported by INT. Current wavelength ranges and Signal/Noise figures are:

B: orders 149 – 103, λ 3800 – 5510 Å

R: orders 109 – 63, λ 5150 – 9000 Å

λ (nm) ... S/N per res elt (10 km/s) in 40 mn on mV=7 A0 star
400 200
500 450
600 540
700 510
800 440

The proposals for INT are selected by a Panel For the Allocation of Telescope Time (PATT) . The time is shared between INT international partners as 60Also 5 yearly.

We wish to know whether you are considering submitting an application for using the ESA-MUSICOS spectrograph at INT on: semester 98 A Feb-Jul 98 proposal deadline 30 Sept. 97 semester 98 B Aug98-Jan 99 proposal deadline 31 March 98

This would allow us to organise technical and scientific support for the ESA-MUSICOS observations, optimise operations or see whether some proposals could be merged or coordinated. Also we could assess whether ESA-MUSICOS could support some coordinated (multi-site or with space) campaigns under preparation. You might be aware that we shall discuss targets for future MUSICOS multi-site campaigns at an ESO workshop on 14-18 October.

Could we ask you to send us the following information:

Proposal title:
PI name:
Co-Is from INT institutions:
Short description of programme:
Number of nights:
Main targets:
Optimum period to be requested in 98:
Coordination with other observatories (space or multi-site):

For further information, please contact us:

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In Memoriam: P. Brendan Byrne (1947 - 1997)

Dr. Patrick Brendan Byrne, Research Astronomer at Armagh Observatory, died on 16 September 1997 at the tragically early age of 49 whilst on an observing trip to the island of La Palma, in the Canary Islands, Spain. Born in Dublin on 28 September 1947, Brendan always had a love of astronomy and had a natural flair for scientific thought. He entered University College Dublin in 1966, graduating with a degree in Experimental Physics in 1970, and then worked for his Ph.D. at Dunsink Observatory. During this time he travelled to South Africa in order to use the Armagh-Dunsink-Harvard telescope in a novel experimental configuration to search for optical pulses from the black hole that was believed, even then, to exist at the centre of the Galaxy. In 1974, following this apprenticeship, he became a post-doctoral research fellow at Dunsink, and in 1977 obtained a lectureship in the Astronomy Department of the University of Cape Town. He joined the Armagh Observatory as a Research Astronomer in 1978.

His period at Armagh saw many changes, both in the quality of research facilities and in the breadth of research carried out at the Observatory. He was particularly closely involved in the introduction of new computing equipment and, with others, in the acceptance by the Department of Education Northern Ireland and the UK Science and Engineering Research Council that Armagh Observatory was entitled — in the same way as a University Department — to apply for research grants and post-doctoral positions. Dr. Byrne was Assistant Director of the Armagh Observatory from 1989 to 1996, and his advocacy and promotion of the strengths of the Observatory at all levels sowed the seeds of the continuing expansion of research at Armagh Observatory, making it currently one of the UK's leading astronomical institutes. Brendan was also a strong supporter of the Astronomical Science Group of Ireland, which has organized biannual astronomical meetings for the past 23 years and provides an important forum for the Irish astronomical community to interact, and to discuss topics of current interest and future plans.

Brendan's own area of research focused on stellar astrophysics: the study of star spots; the mechanisms by which the outer layers of stars are sometimes heated to temperatures of millions of degrees; the energetics of powerful eruptions of hot gas; and the processes by which hot gas, as in the solar corona, sometimes condenses and "rains down" on to the stellar surface. He was a world authority in all these fields, exerting influence not only through numerous national and international collaborations but also on scientific committees: work for which the astronomical community is indebted and to which he gave generously of his time.

His most recent project was to understand the development of stellar rotation from the early rapidly rotating phase associated with star formation to the later stages of much slower rotation, similar to that observed in stars the age of the Sun. How is angular momentum gained and lost; at what stage of stellar evolution are changes most rapid; and what do the observed rotational velocities of stars, for example those formed at the same time in a single star cluster, tell us about the history of our Sun and the ages of distant stars?

Brendan was a leading expert in space astronomy and actively involved in projects that used space facilities such as the International Ultraviolet Explorer, ROSAT, and the Hubble Space Telescope. He was also familiar with the use of many telescopes abroad, and made frequent observing trips to places such as South Africa, Australia, La Palma, Chile and the observatories of North America. It was during one of these observing trips that Brendan was taken ill and died. Despite his lack of years he published 150 scientific papers and numerous popular articles, and gave many professional scientific talks. He was frequently invited to present papers at major international conferences, but still found time to promote astronomy and to give talks on all possible subjects to the general public. Brendan made a deep impression not only on the Armagh Observatory but also on the UK, Irish and world-wide astronomical community. He would sometimes remark that he was fortunate to be paid to do his "hobby"; his colleagues are fortunate to have had the privilege to know and to work with him.

Brendan Byrne was a warm, hospitable person, with a keen sense of humour, generous with his time (particularly to his numerous students and research assistants) and provocative both in thought and expression. He was extraordinarily efficient at handling the administrative minutiae of modern astronomical science, and prolific in his scientific output. Although not an iconoclast, he was always prepared to countenance views which went against the main stream and, if the standard reasoning appeared unsound, was happy to play "devil's advocate". A measure of the man is that he developed personal relationships and friendships with his scientific colleagues which were life-long. He will be sadly missed by us all.

J.G. Doyle

Ideas Solicited for P.B. Byrne Memorial

Bernard Foing (ESTEC) has proposed that a memorial contribution to P.B. Byrne be organized, perhaps in the form of a memorial symposium. If you have comments or suggestions on the nature of such a memorial, please contact Dr. Foing at BFOING@estec.esa.nl.

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` .