COOLNEWS

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We present the first Doppler image of the rapidly-rotating G5 giant in the unusual IN Comae triple system. Our average image from three spectral regions and two continuum color indices shows mostly low to high latitude features but not a prominent polar cap-like spot. A parameter study of the stellar and atomic input quantities aims to better quantify the reliability of our Doppler image.

A time series of 330 high-precision Strömgren *by* and Johnson V measurements in 1996 show only one *real* photometric period (5.913±0.005 days) that we interpret to be the rotation period of the G5 giant. We found no evidence for the 0.25-day period claimed earlier by Kuczawska & Mikolajewski.

Optical spectra of several activity indicators are presented and discussed. IN Comae exhibits an unusual broad Hα emission line and a central absorption feature. This profile shape is also seen for the Ca II infrared-triplet lines as well as for the sodium doublet and the He I D_3 line. No Li I 6707.8 line is present. New radial velocity measurements from our red-wavelength spectra do not indicate a short-period binary but would be consistent with the G5 star being the outer, third component of this triple system.

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On the Cycle Periods of Stellar Dynamos

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We show that the cycle periods ($P_{\rm cyc}$) of slowly rotating lower main-sequence stars with *well-defined* periodic chromospheric activity can be parametrized by the rotation period ($P_{\rm rot}$) and the convective turnover time ($\tau_{\rm c}$) through a relation of the form $P_{\rm cyc} \propto P_{\rm rot}^{b} \tau_{\rm c}^{c}$, with $b = 2.0 \pm 0.3$ and $c = -2.0 \pm 0.3$. This suggests a common dynamo mechanism for slowly rotating lower main-sequence stars. Using a simple linear mean-field dynamo model, we are able to reproduce the observed relation if $\Delta\Omega$, the total difference in angular velocity along the radial direction, scales as $\Delta\Omega \propto P_{\rm rot}^{p}$ with $p = 1.1 \pm 0.2$, and if the α-coefficient scales as $\alpha \propto {\rm Ro}^{q}$ with $q = -5.1 \pm 0.6$. This would suggest that, with increasing rotation rate, differential rotation decreases while $|\alpha|$ rapidly increases.

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Lithium Abundances in the Young Open Cluster IC 2602

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We have obtained high-resolution spectra for 28 candidate late–type stars in the 30 Myr old cluster IC 2602. NLTE Li abundances have been derived from measured equivalent widths. The log n(Li) – $T_{\rm eff}$ and log n(Li) – mass distributions for our sample stars have been compared with those of the Pleiades and α Persei. Our data show that F stars in the three clusters have the same lithium content, which corresponds to the initial content for Pop. I stars. G and early-K IC 2602 stars are, on average, somewhat more Li-rich than their counterparts in the two slightly older clusters. Finally, the latest-type IC 2602 stars are heavily Li depleted, with their Li content being as low as the lowest measured among the Pleiades. As in the Pleiades and α Per, a star-to-star scatter in lithium is observed among 30 Myr old late-K/early-K dwarfs in IC 2602, indicating that this spread develops in the pre–main sequence phases.

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Pleiades Low-mass Binaries: Do Companions Affect the Evolution of Protoplanetary Disks?

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We have observed 144 G and K dwarf members of the Pleiades cluster to search for close multiple systems using CFHT's Adaptive Optics adaptor in the near-IR. We detected 22 binary systems and 3 triples, with a separation between 0.08 and 6.9 arcsec (11–910 AU). After correction for incompleteness, we derive a binary frequency in the orbital period range from 4.2 to 7.1 log days, of 28 ± 4% for G and K Pleiades dwarfs, similar to that of field G-type dwarfs (27%). The distributions of both orbital periods and mass-ratios of the Pleiades systems also appear similar to those of G dwarf binaries of the field. The binary frequency in the 100 Myr-old Pleiades cluster is much lower than that observed for Myr-old pre-main sequence (PMS) stars in the Taurus-Auriga cloud. We argue that this difference does *not* result from the evolution of the binary systems during the pre-main sequence. Instead, we suggest that the low Pleiades binary frequency is typical of stellar populations formed in dense protoclusters, while the higher binary frequency observed among Tau-Aur PMS stars is more typical of loose T associations. The implication is that most field stars are born in dense protostellar clusters.

All 144 surveyed stars have known rotational velocities. Based on the current beliefs that i) the rotation rate of Pleiades late-type dwarfs is largely dictated by the lifetime of their pre-main sequence circumstellar disks and that ii) the evolution of the disks is affected by the presence of a close companion, we searched for a relationship between rotational velocity and binarity among Pleiades G and K dwarfs. We find no significant difference between the distribution of rotational velocities of single and binary stars. Unless current models of PMS angular momentum evolution are flawed, this indicates that the presence of a companion within a distance of 10-1000 AU does not prevent accretion from occurring onto the primary at a rate similar to that observed for single PMS stars. For the closest systems, this implies that accretion must proceed from the *circumbinary* disk onto the central stars. For slightly wider systems, it suggests that the truncated circumstellar disks of the primary and of the secondary are fed by an external (circumbinary) reservoir of mass.

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

Multiwavelength Optical Observations of Chromospherically Active Binary Systems. I. Simultaneous Hα, Na I D$_1$, D$_2$, and He I D$_3$ Observations

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This is the first paper of a series aimed at studying the chromosphere of active binary systems using the information provided for several optical spectroscopic features. Simultaneous Hα, Na I D$_1$, D$_2$, and He I D$_3$ spectroscopic observations are reported here for 18 systems. The chromospheric contribution in these lines have been determined using the spectral subtraction technique.

Very broad wings have been found in the subtracted Hα profile of some of the more active stars. 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.

Prominence-like extended material has been detected in a near-eclipse Hα observation of the system AR Lac.

The excess emission found in the Na I D$_1$ and D$_2$ lines by application of the spectral subtraction technique and the behaviour of the Hα line in the corresponding simultaneous observations indicate that the filling-in of the core of these lines is a chromospheric activity indicator.

For giant stars of the sample the He I D$_3$ line has been detected in absorption in the subtracted spectra.

An optical flare has been detected in UX Ari and II Peg through the presence of the He I D$_3$ in emission in coincidence with the enhancement of the Hα emission.

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An Active K0 IV-V star and a Hot Dwarf (EUVE J0702+129) in a Wide Binary

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We present far ultraviolet and optical spectroscopy of the Extreme Utraviolet Explorer (EUVE) survey source EUVE J0702+129 revealing a composite KO star plus DA white dwarf spectrum. The International Ultraviolet Explorer spectra show continuum emission from a hot white dwarf (T_{eff} = 30 - 40,000 K) and a rising contribution from the KO star at $\lambda \geq 2500$Å. High resolution optical spectroscopy uncovers a high level of activity with strong H α and Ca H&K emission; application of the Wilson-Bappu relation indicates that the secondary star is slightly above the

main sequence (KO IV-V). Both objects are found at a distance of ~130 pc and they likely constitute a physical pair. The EUV emission is dominated by the white dwarf, but the late-type star certainly contributes at higher energy. An interesting parallel is drawn with other DA+KO pairs with moderately active secondaries such as HD 18131 and HR 1608. The present discovery as well as other recent ones demonstrate the existence of a large population of white dwarfs hidden by evolved companions (III-IV).

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EUV Emission from RS CVn Binaries

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We performed a study of 104 RS CVn systems in the extreme ultraviolet (EUV) using the all–sky survey data obtained by the Extreme Ultraviolet Explorer (EUVE). The present sample includes several new RS CVn detections; 11 more than in the published EUVE catalogs, and 8 more than in the ROSAT Wide Field Camera catalog. The ratio of detections to non–detections remained constant throughout the sky, implying that our detections are not limited by the exposure time but are most likely limited by absorption from the interstellar medium. A general trend of increasing Lex/B (50–180Å) flux with decreasing rotational period is clear. The dwarf systems exhibit a leveling-off for the faster rotators. In contrast, the evolved systems exhibit no such effect. For the RS CVn systems the losses in the EUV represent a smaller fraction of the coronal radiative losses, as compared to active late–type dwarfs.

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Carbon Stars with Detached Dust Shells: The Circumstellar Envelope of UU Aurigae

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We have modelled the spectral energy distribution of the carbon-rich star UU Aurigae, which shows an excess flux in the far infrared and sub-millimeter regions, in terms of a detached shell generated by an episode of higher (than the current) mass loss rate. Two different compositions for the detached shell were used: oxygen-rich and carbon-rich dust grains. By assuming that at longer wavelengths the extinction coefficients of the oxygen-rich grains follow a λ^{-2} law, and those of the amorphous carbon follow a $\lambda^{-1.3}$ law, we show that the model including a detached carbon-rich shell produces a more satisfactory fit to the observational data compared to the model with a detached oxygen-rich shell. Moreover, we derived a relatively small value for the distance of the detached shell from the central star, which implies that the episode of high mass loss rate ended only few hundred years ago.

The results of our analysis are consistent with the scenario for the stellar evolution on the asymptotic giant branch which predicts a short time-scale modulation of the mass loss rate induced by repeated Helium shell-flashes.

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Eclipse Mapping of Starspots on XY UMa in 1992 and 1995

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We present and analyze V-band light curves of the detached eclipsing binary system XY UMa, obtained in 1992 October, 1995 March & November, and 1996 February. The light-curve morphology of this system is known to vary on time-scales of a few days. We have used eclipse-mapping techniques to search for evidence that cool starspots are the agents responsible for the variability of the light curve. We derive a new set of geometric system parameters, which we find to be very similar to those derived by Hilditch & Bell (1994). The image derived from the 1992 light curve shows an amorphous band of unresolved spots with a low filling factor, extending over much of the inward-facing hemisphere of the primary. This result is consistent with the extent of the dark-zone model proposed by Hilditch & Bell in their earlier analysis of this same light curve. Irregularities in the primary eclipse profile observed in 1995 and early 1996 are consistent with the eclipse of a dark spot or spots on the inner face of the primary. The major spot in this region appears to be resolved on our 9-degree surface grid, indicating that the spot consists of an unbroken umbral region some 15 degrees in radius.

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Eclipse Mapping of Late-type Close Binary Stars

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The presence of abnormally bright or dark regions on the inner face of either component of an eclipsing binary produces observable distortion of the eclipse profile in a broad-band light curve. The changes in the light level as the eclipsing component scans across the inner face of its companion can be used to reconstruct the surface brightness distribution in the eclipsed region. The purpose of this paper is to describe a code that uses the Maximum Entropy Method (MEM) for eclipse-mapping. Light-curves synthesized with the code are found to give close agreement with results obtained using Hill's LIGHT2 light-curve synthesis code. Reconstructions using simulated data sets derived from known starting images are used to assess the performance of the code and the sensitivity of the reconstructed images to small systematic errors in the eclipse geometry.

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The Angular Diameter of R Doradus: A Nearby Mira-like star

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We find the angular diameter of R Doradus to be 57 ± 5 mas, exceeding that of Betelgeuse and implying that R Dor is larger in apparent size than every star except the Sun. R Dor is shown to be closely related to the Mira variables. We estimate an effective temperature of 2740 ± 190 K, a distance of 61 ± 7 pc, a luminosity of $6500 \pm 1400\, L_{\odot}$ and a radius of $370 \pm 50\, R_{\odot}$. The characteristics of R Dor are consistent with it being near the edge of a Mira instability strip.

We detect non-zero closure phases from R Dor, indicating an asymmetric brightness distribution. We also observed W Hya, a small-amplitude Mira, for which we find an angular diameter of 44 ± 4 mas.

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Starspot Photometry with Robotic Telescopes. Continuous UBV and $V(RI)_C$ Photometry of 23 Stars in 1991–1996

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We report on the progress of our ongoing photometric monitoring program of spotted late-type stars with automatic photoelectric telescopes (APTs) on Mt. Hopkins in Arizona and on Mt. Etna in Sicily. We present 9,250 differential UBV and/or $V(RI)_C$ observations for altogether 23 chromospherically active stars, singles and binaries, pre main sequence and post main sequence, taken between 1991 and 1996. The variability mechanism of our target stars is mostly rotational modulation by an asymmetrically spotted stellar surface. Therefore, precise rotational periods and their seasonal variations are determined using baselines between 3 years for HD 129333 to 34 years for V410 Tauri. We report the largest V light-curve amplitude of any spotted star observed to date: $0.^m65$ for V410 Tau in 1994–95. Long-term variations of the overall light levels of our target stars are sometimes of similar amplitude as the rotational modulation itself and are most likely caused by an analog of the solar 11-year spot cycle but mostly without a well-defined periodicity. For some of our target stars (HD 12545, HD 17433, EI Eri, V410 Tau, LQ Hya, and HD 106225) we estimate a probable cycle period. A complete light curve of the semi-regular S-type giant HR Pegasii is presented. All data are available via the WorldWideWeb from CDS or from Vienna.

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The Limited Influence of Pressure Gradients on Late-type Stellar Line Asymmetries

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Line asymmetries and shifts are a powerful tool for studying velocity fields in the stellar photospheres. Other effects, however, could also generate asymmetries blurring the information of the velocity patterns. We have studied the shifts and asymmetries induced in the profiles of spectral lines by pressure effects. The best theoretical and experimental data on line broadening and shifts caused by collisions with atomic hydrogen were used to analyze the NaI D and three CaI lines. Line bisectors of synthetic spectra computed with accurate data for the NaI and CaI lines are compared with very high resolution high signal-to-noise ratio solar spectra and indicate that pressure broadening reproduces the wings of the observed lines, but pressure shifts introduce neither asymmetries nor shifts comparable to the observed ones.

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On the Comparison Between Spectroscopic and Photometric Metallicity Measurements in Active Solar-type Stars

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We present spectroscopic determinations of the Fe abundance in a sample of K-type stars selected from the *Einstein* Extended Medium Sensitivity Survey, an X-ray flux limited survey. These stars have been shown to have a low value of the m_1 Strömgren photometric indices implying low metal abundances, similar to the abundance observed in Pop. II stars. Yet these cool stars are not necessarily expected to be metal-poor, being most likely young and thus metal-rich. Based on an equivalent width-based abundances analysis which uses high resolution spectra in the region around the Li I 6707.8 Å doublet, we show that none of the stars investigated shows any evidence for low metal abundances. Rather, all have solar or even slightly super-solar abundances. Thus, for very active K stars, photometric metallicity determinations appear to be strongly biased, with the stars appearing to be of much lower metallicity than they actually are. These stars are estimated to be coeval or younger than that of the Pleiades. If, as we argue, the bias in the photometric indices depends purely on the high activity level of these stars, it is then likely that all stars sufficiently young to have similar activity levels would display similar photometric anomalies. We then predict that a non negligible fraction of the disk population K-type stars are expected to show comparable anomalies in their photometric indices. These stars will masquerade as Pop. II stars in photometric survey, and significantly contaminate Pop. II star samples selected on the basis of photometric properties alone down to quite faint magnitudes.

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UBV(RI)$_c$ Photometry of the Rapidly Rotating K-type Star HD 197890 = "Speedy Mic"

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We present accurate UBV(RI)$_c$ differential photometry of the extremely fast rotating single K-type star HD 197890 (= *"Speedy Mic"*). A photometric period of 0.380±0.004 days is inferred. The V-band light curve has a peak-to-peak amplitude of about 0.1 magnitudes and the color variations appear in phase with the V-band modulation. We also infer a mimimum stellar radius in the range 1.13-1.43 $R_\odot$, thus supporting the hyphothesis that HD 197890 is a pre-main sequence star.

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Line Emission in Stellar Envelopes

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We examine the problem of what could be called a 'compact planetary nebula' in studying the radiative equilibrium of a spherical envelope with inner radius comparable or equal to the radius of the illuminating core. The envelope is composed of hydrogen atoms in statistical equilibrium and photoionized by a central radiation of relatively high temperature $T_* > 15\,000$ K. We consistently solve the equations of radiative transfer in spherical geometry for all lines and continua, including the Lyman transitions, together with the equations of statistical equilibrium. Yet we ignore the energy-balance equation and consider the electronic temperature as a given parameter. We show that Balmer and other subordinate lines may appear in emission, even at low temperature, provided that (i) the density is low enough for the radiative terms to partly control the populations of the levels and (ii) the geometrical extension of the H II region is significant. Although the present model is only intended to isolate and illustrate a specific physical mechanism, we suggest that the emission features detected in the spectrum of cool giant or supergiant stars could result from purely radiative processes, at least in some cases.

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The Hyades Binary Finsen 342 (70 Tauri): A Double-Lined Spectroscopic Orbit, the Distance to the Cluster, and the Mass-Luminosity Relation

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We present new radial velocity measurements for both components of the close ($\rho \approx 0''.1$) visual binary ϕ 342 in the Hyades cluster. We combine speckle and visual observations with our velocities to derive an astrometric-spectroscopic orbital solution. This yields individual masses for the stars ($M_{\rm A} = 1.363 \pm 0.073$ $M_\odot$ and $M_{\rm B} = 1.253 \pm 0.075$ $M_\odot$) as well as an orbital parallax for the system ($\pi_{\rm orb} = 0''.02144 \pm 0''.00067$). We use relative proper motions to transfer this orbital parallax to 53 representative cluster members, and derive a distance to the cluster of 47.4 ± 2.3 pc ($m-M = 3.38 \pm 0.11$), which is only 1% closer than the cluster distance derived recently from the orbital parallax for 51 Tauri, another astrometric-spectroscopic binary in the Hyades (Torres, Stefanik, & Latham 1997, ApJ, 474, 256).

We compare the masses and luminosities we derive for ϕ 342, along with those of two other binaries in the Hyades (vB 22 and 51 Tau), with isochrones computed for the cluster, and find that there is good agreement for an age of 630 Myr and metallicity $Z = 0.027$. Because the distances to these binaries have been determined directly, no arbitrary shifts have been applied, as is usually done when fitting main-sequences. These results therefore provide a fundamental test of the mass-luminosity relation as predicted by recent stellar evolution models.

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Rotational Velocities of Late-Type Stars

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A calibration based on the results of Gray has been used to determine projected rotational velocities for 133 bright stars with spectral types of F, G, or K, most of which appear in *The Bright Star Catalogue*. The vast majority have $v \sin i \leq 10$ km s^{-1} and, thus, are slow rotators. With the new calibration, projected rotational velocities have been determined for a sample of 111 late-type stars, most of which are chromospherically active. Some of the stars have had their rotational velocities measured for the first time.

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New and Improved Parameters of HD 202908 = ADS 14839: A Spectroscopic-Visual Triple System

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HD 202908 = ADS 14839 is a spectroscopic-visual triple system consisting of three solar-type stars. Eighteen years of spectroscopic observations including coverage of the recent periastron of 1987 January plus visual and speckle observations, the latter covering roughly the same interval as the radial velocities, have been used to obtain a simultaneous three-dimensional orbital solution. The short-period pair, Aa and Ab, has an orbital period of 3.9660465 days and a small but real eccentricity of 0.0033. The visual pair, A and B, has an orbital period of 78.5 yr and an eccentricity of 0.865. The solution yields masses for all three stars with uncertainties of about 2% and the distance

to the system with an uncertainty of 1.3%. Spectroscopic luninosity ratios, combined with the above distance, yield absolute magnitudes with uncertainties of about 0.1 mag. Thus, the system provides three well-determined points on the mass-luminosity relationship. The inclinations of the short-period and long-period orbits differ by 29 deg, making the orbits non-coplanar. Assuming synchronous rotation, the rotational and orbital axes of the short-period pair are aligned. The chromospheric emission, lithium abundance, and projected rotational velocity of component B indicate that the system is quite young, probably about the age of the Hyades Cluster. A comparison with theoretical evolutionary tracks supports such a conclusion.

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Brown Dwarfs in the Pleiades, A deep IJK Survey

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An area large enough (180 arcmin^2) to put constraints on a possible low mass brown dwarf population in the Pleiades has been surveyed to very faint magnitudes in I, J and K. The completeness limit, I=21.6, corresponds to a mass of 0.01 $M_\odot$ for a cluster age of 70 Myr and 0.035 $M_\odot$ for 120 Myr. The result is consistent with previous investigations at higher masses that the brown dwarf initial mass function is a m^{-1}, or even less steep , power law. Thus low mass brown dwarfs cannot contribute significantly to the Pleiades' mass. One new possible Pleiades member was found, mass ~ 0.08 $M_\odot$ (age 120Myr).

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The Onset of Photometric Variability in Red Giant Stars

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The onset of variability in red giant stars is studied from the data collected by the 'Long-Term Photometry of Variables' project which operates at ESO (La Silla) since 1982. The differential nature of the observations combined with a multi-night reduction algorithm enables us to study the variability of over 50 red giants with an accuracy of the order of 2 to 3 millimagnitudes on time scales ranging from days to years. All red giants with spectral types late G to early K (i.e. $b - y \sim 0.6 - 0.8$) are stable at the level $\sigma_{\rm y} < 6$ millimag (where $\sigma_{\rm y}$ is the standard deviation of the Strömgren y magnitude). Red giants with later spectral types are all variable, and it is found that the minimum variability level $\sigma_{\rm y,min}$ increases with increasing $b - y$, thus defining a *minimum-variability boundary*. The new data obtained in this paper reveal that the time scale of the associated variability increases with increasing $b - y$ (and thus amplitude), and that the stability of this time scale improves concomitantly. More precisely, irregular variations on time scales of 5 to 10 days (and $\sigma_{\rm y} \sim 7$ millimag) characerize red giants with $b - y \sim 1.0$, whereas the variations (with $\sigma_{\rm y} \sim 100$ millimag) become more regular with periods of the order of 50 d for red giants with $b - y \sim 1.3$. A radial-velocity jitter (of the order of 1.5 km s^{-1} r.m.s.) is associated with this photometric variability, and suggests that stellar oscillations may be responsible for the observed variations.

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

The Primordial Lithium Abundance

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Lithium abundances in a selected sample of halo stars have been revised by using the new accurate IRFM effective temperatures by Alonso, Arribas & Martinez-Roger (1996a). From 41 plateau stars ($T_{eff} > 5700$ and [Fe/H] $\leq$ -1.5) we found no evidence for intrinsic dispersion, a tiny trend with T_{eff} and no trend with [Fe/H]. The trend with the T_{eff} is fully consistent with the standard Li isochrones of Deliyannis, Demarque & Kawaler (1990) implying a primordial value for Li of A(Li)= $2.238 \pm 0.012_{1\sigma} \pm 0.05_{sys}$. The present results argue against any kind of depletion predicted by diffusion, rotational mixing or stellar winds. Therefore the Li observed in Pop II stars provides a direct and reliable estimate of the baryonic density that can rival other baryonic indicators such as the deuterium in high redshift systems. The present upwards revision of primordial Li in the framework of SBBN gives at 1σ two solutions for the baryonic density: $\Omega_B h^2 = 0.0062^{+0.0018}_{-0.0011}$ or $\Omega_B h^2 = 0.0146^{+0.0029}_{-0.0033}$.

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EUV Activity in Late-Type Stars During the ROSAT WFC All-Sky Survey. I. Techniques and Initial Results.

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We have studied 127 active late-type stars, including all well known flare stars, in the extreme ultraviolet region of the electromagnetic spectrum, using the ROSAT Wide Field Camera survey observations. Our analysis included photometry for all the stars in the sample, timing analysis of the observed photon events and a statistical analysis for possible small-scale low-level variability. 49 stars in our sample were detected in one or both EUV wavebands. A total of 35 flares were seen, from 23 stars, not all of them well known flare stars. In addition, about half of the detections exhibited low-level variability. Further analysis revealed that the observed low-level variability was not due to rotational or orbital modulation but rather was related to small-scale activity on the stars, possibly in the form of small-amplitude flare-like events which are too faint to be recognized as individual flares at the sensitivity of the WFC. We call this low-level activity "milliflaring".

We also give estimated upper limit count rates for the non-detections.

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New Perspectives on AX Monocerotis

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AX Monocerotis is a 232^d, non-eclipsing, interacting binary star which consists of a K giant, a Be-like giant, and large amounts of circumstellar material. The K star is almost certainly a synchronous rotator and probably in contact with its critical lobe. The Be star was believed to be a rapid rotator based on extremely wide absorption lines, but new spectra show that these lines arise from the circumstellar environment. Hydrogen emission, also circumstellar, is many times stronger than the continuum. Near-ultraviolet light curves exhibit a $0.^m5$ dip near phase 0.75, but there is no such variability at longer wavelengths. Gas flow trajectories from the cusp of the K star toward the Be star provide a simple explanation for the photometric and spectroscopic behavior. We may have found a decreasing orbital period, but more data are necessary to confirm this result. We present several models for AX Mon based on 1) new and archival visible photometry, 2) archival ultraviolet spectroscopy, 3) new and archival visible spectroscopy, 4) new visible polarimetry, and 5) new radio photometry. Future observations, including optical interferometry, are proposed.

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The X-Ray Sun in Time. A Study of the Long-Term Evolution of Coronae of Solar-Type Stars

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We have used the ASCA and ROSAT X-ray satellites to probe the coronae of a sample of nine solar-like G-stars. These stars are all ostensibly single with ages ranging from 70 Myr to 9 Gyr, and have X-ray luminosities ranging from 1–500 times that of the quiet Sun. Specifically, we investigate the dependence of the coronal temperature and emission measure structure of these stars on age and rotation period.

In the younger stars, a considerable portion of the volume emission measure resides at very high temperatures, reaching up to $\sim 20-30$ MK in EK Dra. Such temperatures are comparable to temperatures that are achieved on the Sun during short flaring episodes. In 2-temperature fits to ROSAT data, the higher temperature decays rapidly within the first few 100 Myr; the decay may be described by an inverse power-law, $T_{\rm hot} \propto {\rm age}^{-0.3}$. We also find a power-law dependence between the total X-ray luminosity and the higher temperature $L_{\rm X} \propto T_{\rm hot}^4$. We interpret this as evidence of a decrease in the efficiency of high-temperature coronal heating as a solar-like star ages and its rotation slows down. A reconstruction of the coronal differential emission measure (DEM) distribution in three of the stars using ASCA data indicates a bimodal distribution in temperature, with the hotter plasma at 12–30 MK and the cooler plasma below 10 MK. We infer, for the first time, a consistent evolution of the DEM structure in a solar-type star. The emission measure of the hotter component rapidly decreases with age and becomes unimportant at ages beyond ~ 500 Myr. The emitted X-ray emission of the young Sun thus rapidly softened, which had important implications for the young planetary atmospheres. We suggest that the high-temperature component is the result of superimposed but temporally unresolved flaring events, and support this picture by reconstructing the time-integrated (average) emission measure distribution of typical solar X-ray flares. Radio observations of active stars fit well into this picture, and suggest that the presence of nonthermal electrons in coronae is linked to the presence of hot (> 10 MK) plasma, very much the same situation as in solar flares. We find, however, that radio emission saturates, if at all, at smaller rotation periods than does X-ray emission.

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Testing the Stability and Reliability of Starspot Modelling

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Since the mid 70's different starspot modelling techniques have been used to describe the observed spot variability on active stars. Spot positions and temperatures are calculated by application of surface integration techniques or solution

of analytic equations on observed photometric data. Artifical spotted light curves were generated, by use of the analytic expressions of Budding (1977), to test how the different constraints like the intrinsic scatter of the observed data or the angle of inclination affects the spot solutions. Counteractions between the different parameters like inclination, latitude and spot size were also investigated. The results of re-modelling the generated data were scrutinized statistically. It was found, that (1) $0.002 - 0.005$ mag. of photometric accuracy is required to recover geometrical spot parameters within an acceptable error box; (2) even a $0.03 - 0.05$ mag error in unspotted brightness substantially affects the recovery of the original spot distribution; (3) especially at low inclination, under- or overestimation of inclination by 10° leads to an important systematic error in spot latitude and size; (4) when the angle of inclination $i \lesssim 20°$ photometric spot modelling is unable to provide satisfactory information on spot location and size.

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Solar Abstracts

Flows and Dynamics in the Corona Observed with the Coronal Diagnostic Spectrometer (CDS)

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EUV spectra obtained with the Coronal Diagnostic Spectrometer (CDS) on the Solar and Heliospheric Observatory (SOHO) show significant flows of plasma in active region loops, both at coronal and transition region temperatures. Wavelength shifts in the coronal lines Mg IX 368 Å and Mg X 624 Å corresponding to upflows in the plasma reaching velocities of 50 km s^{-1} have been observed in an active region. Smaller velocities are detected in the coronal lines Fe XVI 360 Å and Si XII 520 Å. Flows reaching 100 km s^{-1} are observed in spectral lines formed at transition region temperatures, i.e. O V 629 Å and O III 599 Å, demonstrating that both the transition region and the corona are clearly dynamic in nature. Some high velocity events show even higher velocities with line profiles corresponding to a velocity dispersion of 300-400 km s^{-1}. Even in the quiet Sun there are velocity fluctuations of 20 km s^{-1} in transition region lines.

Velocities of the magnitude presented in this paper have never previously been observed in coronal lines except in explosive events and flares. Thus, the preliminary results from the CDS spectrometer promise to put constraints on existing models of the flows and energy balance in the solar atmosphere. The present results are compared to previous attempts to observe flows in the corona.

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The Distribution of Cell Sizes of the Solar Chromospheric Network

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This paper studies the cellular pattern of the supergranular network. We present an algorithm to draw a surface-filling cell pattern on an uninterrupted two-day sequence of Ca II K filtergrams in a 1 nm bandpass. The 60 deg ×40 deg field of view contains both quiet and enhanced network, and plages. The algorithm uses a threshold independent method of steepest descent on spatially smoothed and time-averaged images. We determine the distribution function of cell areas and find a broad, asymmetric spectrum of areas. The distribution is found to be invariant for different spatial smoothings, if the cell areas are normalized to unit mean. It is this invariance that leads us to believe we have determined the intrinsic distribution of cell areas. Extrapolation of the average cell size to zero spatial smoothing

yields a characteristic cell diameter of L =13-18 Mm. This is roughly half the generally quoted supergranular length scale $L \approx 32$ Mm as determined with autocorrelation methods since Simon & Leighton (1964). The difference in characteristic cell size reflects the application of a different measurement method: the autocorrelation method as used by Simon & Leighton and others is preferentially weighed towards relatively large cells. We find no significant dependence of cell size on local magnetic flux density.

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Nonthermal Velocities in the Solar Transition Zone and Corona

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Nonthermal velocities are presented for spectral lines covering the temperature range $10^4K - 10^6$ K, measured from high spectral resolution data for several solar features observed at the limb by the High Resolution Telescope and Spectrograph (HRTS), including a coronal hole, 'quiescent regions' and several small scale active regions. These results are compared with predictions based on acoustic waves and heating via Alfven waves. It is likely that more than one mechanism is operating simultaneously, in particular, resonant Alfven wave heating, which is very sensitive to background plasma motions.

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Formation of Solar Calcium H and K Bright Grains

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We have simulated the generation of CaII H_{2V} bright grains by acoustic shocks. We employ a one-dimensional, non-LTE, radiation hydrodynamic code, with 6 level model atoms for hydrogen and singly ionized calcium. We drive acoustic waves through a stratified radiative equilibrium atmosphere by a piston, whose velocity is chosen to match the Doppler shift observed in the FeI λ 396.68 line in the H line wing, formed at about 260 km above $\tau_{500} = 1$.
The simulations closely match the observed behavior of CaII H_{2V} bright grains down to the level of individual grains. The bright grains are produced by shocks near 1 Mm above τ_{500}=1. Shocks in the mid chromosphere produce a large source function (and therefore high emissivity) because the density is high enough for collisions to couple the CaII populations to the local conditions. The asymmetry of the line profile is due to velocity gradients near 1 Mm. Material motion Doppler shifts the frequency where atoms emit and absorb photons, so the maximum opacity is located at – and the absorption profile is symmetric about – the local fluid velocity, which is shifted to the blue behind shocks. The optical depth depends on the velocity structure higher up. Shocks propagate generally into downflowing material, so there is little matter above to absorb the Doppler shifted radiation. The corresponding red peak is absent because of small opacity at the source function maximum and large optical depth due to overlying material. The bright grains are produced primarily by waves from the photosphere that are slightly above the acoustic cutoff frequency. The precise time and strength of a grain depends on the interference between these waves near the acoustic cutoff frequency and higher frequency waves. When waves near the acoustic cutoff frequency are weak, then higher frequency waves may produce grains. The "five-minute" trapped p-mode oscillations are not the source of the grains, although they can slightly modify the behavior of higher frequency waves.

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Cyclical Variability in Stellar Winds:
Recent Developments and Future Applications

Preliminary announcement:
ESO workshop planned for October 14 - 17, 1997, at ESO Headquarters in Garching bei München, Germany.

Scope:
Variability is a fundamental property of stellar winds. In recent years it has become clear that in many cases the observed variations are cyclical. This is a property that hot- *and* cool-star winds seem to have in common, despite the differences in the physics of their respective driving mechanisms.

Topics to be discussed:

- Observations of cyclical wind variability (hot and cool stars)
- Deep-seated processes affecting the emergence of the wind
- Theoretical developments
- Multi-site campaigns (MUSICOS)
- Future developments

Scientific Organizing Committee:
T. Böhm (Germany), A. Cameron (UK), C. Catala (France), L. Hartmann (USA), H. Henrichs (The Netherlands), L. Kaper (Germany), H. Lamers (The Netherlands), K. MacGregor (Chair, USA), S. Owocki (USA), J. Puls (Germany), O. Stahl (Germany)

Local Organizing Committee:
A. Fullerton, L. Kaper, C. Stoffer

Contact:
Lex Kaper (lkaper@eso.org)

Job Announcement

Research Assistantship in Solar Physics at ARMAGH OBSERVATORY

Applications are invited for a 19 month research assistantship in Solar Physics at Armagh Observatory funded by PPARC, with the possibility of an extension. This post will involve the exploration of data from the SOHO mission, in particular, the question of coronal heating & the dynamics of the solar ultraviolet explosive events. Other areas of SOHO interest, include chromospheric oscillations. The job will involve travel to Goddard Space Flight Center. Although the job will involve extensive use of observational data, ideally the candidate should have a good modelling background (e.g. MHD/plasma physics) and have obtained their PhD prior to appointment. Details on the research interests of astronomers at Armagh Observatory and further information on this post may be found on the Internet World-Wide-Web URL: http://star.arm.ac.uk/

Applications, including a CV and the names of three referees should be forwarded before 7 February 1997 to The Secretary, Armagh Observatory, College Hill, Armagh BT61 9DG, N. Ireland. Informal enquires may be obtained from:

Dr J.G. Doyle (email — Solarmail solar::gdoyle and/or Internet jgd@star.arm.ac.uk)

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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