COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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TABLE OF CONTENTS

Stellar Abstracts

Differential Rotation of Some HK-Project Stars and the Butterfly Diagrams

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We analyze the long-term variability of the chromospheric radiation of 20 stars monitored in the course of the HK-Project at the Mount Wilson Observatory. We apply the modified wavelet algorithm for this set of gapped time series. Besides the mean rotational periods for all these stars, we find reliable changes of the rotational periods from year to year for a few stars. Epochs of slower rotation occur when the activity level of the star is high, and the relationship repeats again during the next maximum of an activity cycle. Such an effect is traced in two stars with activity cycles that are not perfectly regular (but labeled "Good" under the classification in [Baliunas, S.L., Donahue, R.A., Soon, W.H., Horne, J.H., Frazer, J., Woodard-Eklund, L., Bradford, M., Rao, L.M., Wilson, O.C., Zhang, Q. et al., 1995. ApJ 438, 269.]) but the two stars have mean activity levels exceed that of the Sun. The averaged rotational period of HD 115404 is 18.5 days but sometimes the period increases up to 21.5 days. The sign of the differential rotation is the same as the Sun's, and the value $\Delta\Omega/<\Omega>= -0.14$. For the star HD 149661, this ratio is -0.074. Characteristic changes of rotational periods occur over around three years when the amplitude of the rotational modulation is large. These changes can be transformed into latitude-time butterfly diagrams with minimal a priori assumptions. We compare these results with those for the Sun as a star and conclude that epochs when surface inhomogeneities rotate slower are synchronous with the reversal of the global magnetic dipole.

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Observation and Modelling of Main Sequence Star Chromospheres X. Radiative Budgets on Gl 867A and AU Mic (dM1e), and a Two-component Model Chromosphere for Gl 205 (dM1)

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We report on high resolution observations of two dM1 stars; Gl 867A an active dM1e star and Gl 205, a less active dM1 star. The wavelength coverage is from 3890Å to 6820Å with a resolving power of about 45,000. The difference spectrum of these two stars allow us to make a survey of spectral lines sensitive to magnetic activity. We chose these two stars because to within measurement errors they have very close properties: Gl 867A has $R=0.726R_\odot$, [M/H]=0.080dex and Teff=3416K, and Gl 205 has $R=0.758R_\odot$, [M/H]=0.101dex and Teff=3493K. We find that besides traditional chromospheric lines, many photospheric lines are "filled-in" in the active star spectrum. These differences are most of the time weak in absolute fluxes but can be large in terms of differences in the spectral line equivalent widths.

We calculate the differences in surface fluxes between these two stars for many spectral lines. We derive the radiative budgets for two dM1e stars: Gl 867A and AU Mic. We show that the sum of the numerous spectral lines represents a significant fraction of the radiative cooling of the outer atmosphere. We also re-investigate the cooling from the continuum from the visible to the extreme ultra-violet: we find that the earlier predictions of the calculations of Paper V are in good agreement with observations. We emphasize that if this radiative cooling is chromospheric in character, then in chromospheric model calculations, one should include the radiative losses in Ca I, Cr I, V I, Ti I and Fe I.

From simple constraints we derive model chromospheres for quiescent and active regions on Gl 205. We show that the quiescent regions have a strong absorption H_α profile. The plage regions show a filled-in intermediate activity H_α profile. We also present possible spectral line profiles of quiescent and active regions on Gl 867A.

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RACE-OC Project: Rotation and Variability in the Open Cluster M11 (NGC6705)

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Rotation and magnetic activity are intimately linked in main-sequence stars of G or later spectral types. The presence and level of magnetic activity depend on stellar rotation, and rotation itself is strongly influenced by strength and topology of the magnetic fields. Open clusters represent especially useful targets to investigate the rotation/activity(age connection. Over the time stellar activity and rotation evolve, providing us with a promising diagnostic tool to determine age of the field stars. The open cluster M11 has been studied as a part of the RACE-OC project (**R**otation and **AC**tivity **E**volution in **O**pen **C**lusters), which is aimed at exploring the evolution of rotation and magnetic activity in the late-type members of open clusters with different ages. Photometric observations of the open cluster M11 were carried out in June 2004 using LOAO 1m telescope. The rotation periods of the cluster members are determined by Fourier analysis of photometric data time series. We further investigated the relations between the surface activity, characterized by the light curve amplitude, and rotation. We have discovered a total of 75 periodic variables in the M11 FoV, of which 38 are candidate cluster members. Specifically, among cluster members we discovered 6 early-type, 2 eclipsing binaries and 30 bona-fide single periodic late-type variables. Considering the rotation periods of 16 G-type members of the almost coeval 200-Myr M34 cluster, we could determine the rotation period distribution from a more numerous sample of 46 single G stars at an age of about 200-230 Myr and determine a median rotation period P=4.8d. A comparison with the younger M35 cluster ($\sim$150 Myr) and with the older M37 cluster ($\sim$550 Myr) shows that G stars rotate slower than younger M35 stars and faster than older M37 stars. The measured variation of the median rotation period is consistent with the scenario of rotational braking of main-sequence spotted stars as they age. Finally, G-type M11 members have a level of photospheric magnetic activity, as measured by light curve amplitude, comparable to that observed in the in younger 110-Myr Pleiades stars of similar mass and rotation.

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For preprints via ftp or WWW: http://fr.arxiv.org/abs/0912.4131

A Volume-limited Sample of 63 M7–M9.5 Dwarfs II. Activity, Magnetism, and the Fade of the Rotation-dominated Dynamo

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In a volume-limited sample of 63 ultracool dwarfs of spectral type M7–M9.5, we have obtained high-resolution spectroscopy with UVES at the Very Large Telescope and HIRES at Keck Observatory. In this second paper, we present projected rotation velocities, average magnetic field strengths, and chromospheric emission from the Hα line. We confirm earlier results that the mean level of normalized Hα luminosity decreases with lower temperature, and we find that the scatter among Hα luminosities is larger at lower temperature. We measure average magnetic fields between 0 and 4 kG with no indication for a dependence on temperature between M7 and M9.5. For a given temperature, Hα luminosity is related to magnetic field strength, consistent with results in earlier stars. A few very slowly rotating stars show very weak magnetic fields and Hα emission, all stars rotating faster than our detection limit show magnetic fields of at least a few hundred Gauss. In contrast to earlier-type stars, we observe magnetic fields weaker than 1 kG in stars rotating faster than $\sim 3\,\mathrm{km\,s^{-1}}$, but we find no correlation between rotation and magnetic flux generation among them. We interpret this as a fundamental change in the dynamo mechanism; in ultracool dwarfs, magnetic field generation is predominantly achieved by a turbulent dynamo, while other mechanisms can operate more efficiently at earlier spectral type.

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$UBV(RI)_c JHK$ Observations of *Hipparcos*-selected Nearby Stars

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We present homogeneous, standardised $UBV(RI)_C$ photometry for over 700 nearby stars selected on the basis of *Hipparcos* parallaxes. Additionally, we list JHK photometry for about half of these stars, as well as L photometry for 86 of the brightest. A number of stars with peculiar colours or anomalous locations in various colour-magnitude diagrams are discussed.

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The First Search for Variable Stars in the Open Cluster NGC 6253 and its Surrounding Field

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The work presents the first high–precision variability survey in the field of the intermediate-age, metal–rich open cluster

NGC 6253. Clusters of this type are benchmarks for stellar evolution models. Continuous photometric monitoring of the cluster and its surrounding field was performed over a time span of ten nights using the Wide Field Imager mounted at the ESO-MPI 2.2m telescope. High–quality timeseries, each composed of about 800 datapoints, were obtained for 250,000 stars. We discovered 595 variables and we also characterized most of them providing their variability classes, periods, and amplitudes. The sample is complete for short periods: we classified 20 pulsating variables, 225 contact systems, 99 eclipsing systems (22 β Lyr type, 59 β Per type, 18 RS CVn type), and 77 rotational variables. The time–baseline hampered the precise characterization of 173 variables with periods longer than 4–5 days. Moreover, we found a cataclysmic system undergoing an outburst of about 2.5 mag. Candidate members were selected by using the colour–magnitude diagrams and period–luminosity–colour relations as well as membership probabilities based on the proper motions. The membership of all the variables discovered within a radius of 8 arcmin from the centre is discussed by comparing the incidence of the classes in the cluster direction and in the surrounding field. We propose a list of 35 variable stars as probable members of NGC 6253.

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Solar Abstracts

The Rotation of the Sun as a Star from the Integrated Coronal Green-Line Emission

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A new representation for the database collected by J. Sykora on the Fe XIV 5303 A line emission observed from 1939 to 2001 is proposed. Observations of the corona at an altitude of 60 arcseconds above the limb reduced to a single photometric scale provide estimates of the emission of the entire visible solar surface. It is proposed to use the resulting series of daily measurements as a new index of the solar activity, GLSun (The Green-Line Sun). This index is purely observational and is free of the model-dependent limitations imposed on other indices of coronal activity. GLSun describes well both the cyclic activity and the rotational modulation of the brightness of the corona of the Sun as a star. The GLSun series was subject to a wavelet analysis similar to that applied to long-term variations in the chromospheric emission of late active stars. The brightness irregularities in the solar corona rotate more slowly during epochs of high activity than their average rotational speed over the entire observational interval. The interval of slower rotation of the irregularities is close to the epoch when the Sun's field represents a horizontal magnetic dipole in each activity cycle, but is somewhat longer than the duration of the polarity reversal in both hemispheres. The difference between the periods for the slower and mean rotation exceeds three days, as is typical for some stars with higher but more irregular activity than the Sun. The importance of these findings for dynamo theory for the origin and evolution of the magnetic fields of the Sun and other late-type stars is briefly discussed.

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An Efficient Approximation of the Coronal Heating Rate for Use in Global Sun-Heliosphere Simulations

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The origins of the hot solar corona and the supersonically expanding solar wind are still the subject of debate. A key obstacle in the way of producing realistic simulations of the Sun-heliosphere system is the lack of a physically motivated way of specifying the coronal heating rate. Recent one-dimensional models have been found to reproduce many observed features of the solar wind by assuming the energy comes from Alfvén waves that are partially reflected, then dissipated by magnetohydrodynamic turbulence. However, the nonlocal physics of wave reflection has made it difficult to apply these processes to more sophisticated (three-dimensional) models. This paper presents a set of robust approximations to the solutions of the linear Alfvén wave reflection equations. A key ingredient to the turbulent heating rate is the ratio of inward to outward wave power, and the approximations developed here allow this to be written explicitly in terms of local plasma properties at any given location. The coronal heating also depends on the frequency spectrum of Alfvén waves in the open-field corona, which has not yet been measured directly. A model-based assumption is used here for the spectrum, but the results of future measurements can be incorporated easily. The resulting expression for the coronal heating rate is self-contained, computationally efficient, and applicable directly to global models of the corona and heliosphere. This paper tests and validates the approximations by comparing the results to exact solutions of the wave transport equations in several cases relevant to the fast and slow solar wind.

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Low-Mass and Substellar Abstracts

Hot Jupiters and the Evolution of Stellar Angular Momentum

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Giant planets orbiting main-sequence stars closer than 0.1 AU are called hot Jupiters. They interact with their stars affecting their angular momentum. Recent observations provide suggestive evidence of excess angular momentum in stars with hot Jupiters in comparison to stars with distant and less massive planets. This has been attributed to tidal interaction, but needs to be investigated in more detail considering also other possible explanations because in several cases the tidal synchronization time scales are much longer than the ages of the stars. We select stars harbouring transiting hot Jupiters to study their rotation and find that those with an effective temperature $T_{\rm eff} > 6000$ K and a rotation period $P_{\rm rot} < 10$ days are synchronized with the orbital motion of their planets or have a rotation period approximately twice that of the planetary orbital period. Stars with $T_{\rm eff} < 6000$ K or $P_{\rm rot} > 10$ days show a general trend toward synchronization with increasing effective temperature or decreasing orbital period. We propose a model for the angular momentum evolution of stars with hot Jupiters to interpret these observations. It is based on the hypothesis that a close-in giant planet affects the coronal field of its host star leading to a topology with predominantly closed field lines. An analytic linear force-free model is adopted to compute the radial extension of the corona and its angular momentum loss rate. The corona is more tightly confined in F-type stars, and in G- and K-type stars with a rotation period shorter than ~ 10 days. The angular momentum loss is produced by coronal eruptions similar to solar coronal mass ejections. The model predicts that F-type stars with hot Jupiters, $T_{\rm eff} > 6000$ K and an initial rotation period < 10 days suffer no or very little angular momentum loss during their main-sequence lifetime. This can explain their rotation as a remnant of their pre-main-sequence evolution. On the other hand, F-type stars with $P_{\rm rot} > 10$ days, and G- and K-type stars experience a significant angular momentum loss during their main-sequence lifetime, but at a generally slower pace than similar stars without close-in massive planets. Considering a spread in their ages, this can explain the observed rotation period distribution of planet-harbouring stars. Our model can be tested observationally and has relevant consequences for the relationship between stellar rotation and close-in giant planets as well as for the application of gyrochronology to estimate the age of planet-hosting stars.

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Abstracts dealing with cool pre-main-sequence (PMS) 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. If you wish to submit a cross-disciplinary abstract on PMS stars, then first submit it to the *Star Formation Newsletter*. After doing so, submit the abstract to *COOLNEWS* accompanied by a short e-mail stating that it has already been submitted to the *Star Formation Newsletter*, and summarizing why it will be of interest to the cool star/solar community at large.

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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