COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Dust, Pulsation, Chromospheres and Their Role in Driving Mass Loss from Red Giants in Galactic Globular Clusters

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Mass loss from red giants in old globular clusters affects the horizontal branch (HB) morphology and post-HB stellar evolution including the production of ultraviolet-bright stars, dredge up of nucleosynthesis products and replenishment of the intra-cluster medium. Studies of mass loss in globular clusters also allows one to investigate the metallicity dependence of the mass loss from cool, low-mass stars down to very low metallicities.

We present an analysis of new VLT/UVES spectra of 47 red giants in the Galactic globular clusters 47 Tuc (NGC 104), NGC 362, ω Cen (NGC 5139), NGC 6388, M54 (NGC 6715) and M15 (NGC 7078). The spectra cover the wavelength region 6100–9900 Å at a resolving power of $R = 110,000$. Some of these stars are known to exhibit mid-infrared excess emission indicative of circumstellar dust. Our aim is to detect signatures of mass loss, identify the mechanism(s) responsible for such outflows, and measure the mass-loss rates.

We determine for each star its effective temperature, luminosity, radius and escape velocity. We analyse the Hα and near-infrared calcium triplet lines for evidence of outflows, pulsation and chromospheric activity, and present a simple model for estimating mass-loss rates from the Hα line profile. We compare our results with a variety of other, independent methods.

We argue that a chromosphere persists in Galactic globular cluster giants and controls the mass-loss rate to late-K/early-M spectral types, where pulsation becomes strong enough to drive shock waves at luminosities above the RGB tip. This transition may be metallicity-dependent. We find mass-loss rates of $\sim 10^{-7}$ to 10^{-5} M$_\odot$ yr^{-1}, largely independent of metallicity.

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The Sun in Time: Activity and Environment

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The Sun's magnetic activity has steadily declined during its main-sequence life. While the solar photospheric luminosity was about 30% lower 4.6 Gyr ago when the Sun arrived on the main sequence compared to present-day levels, its faster rotation generated enhanced magnetic activity; magnetic heating processes in the chromosphere, the transition region, and the corona induced ultraviolet, extreme-ultraviolet, and X-ray emission about 10, 100, and 1000 times, respectively, the present-day levels, as inferred from young solar-analog stars. Also, the production rate of accelerated, high-energy particles was orders of magnitude higher than in present-day solar flares, and a much stronger wind escaped from the Sun, permeating the entire solar system. The consequences of the enhanced radiation and particle fluxes from the young Sun were potentially severe for the evolution of solar-system planets and moons. Interactions of high-energy radiation and the solar wind with upper planetary atmospheres may have led to the escape of important amounts of atmospheric constituents. The present dry atmosphere of Venus and the thin atmosphere of Mars may be a product of early irradiation and heating by solar high-energy radiation. High levels of magnetic activity are also inferred for the pre-main sequence Sun. At those stages, interactions of high-energy radiation and particles with the circumsolar disk in which planets eventually formed were important. Traces left in meteorites by energetic particles and anomalous isotopic abundance ratios in meteoritic inclusions may provide evidence for a highly active pre-main sequence Sun. The present article reviews these various issues related to the magnetic activity of the young Sun and the consequent interactions with its environment. The emphasis is on the phenomenology related to the production of high-energy photons and particles. Apart from the activity on the young Sun, systematic trends applicable to the entire main-sequence life of a solar analog are discussed.

Accepted by the Living Reviews in Solar Physics, http://solarphysics.livingreviews.org/

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Solar Abstracts

Jets or High Velocity Flows Revealed in High-Cadence Spectrometer and Imager Co-Observations?

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We report on active region EUV dynamic events observed simultaneously at high-cadence with SUMER/SoHO and TRACE. Although the features appear in the TRACE Fe ix/x 171A images as jets seen in projection on the solar disk, the SUMER spectral line profiles suggest that the plasma has been driven along a curved large scale magnetic structure, a pre-existing loop. The SUMER observations were carried out in spectral lines covering a large temperature range from 10^4 K to 10^6 K. The spectral analysis revealed that a sudden heating from an energy deposition is followed by a high velocity plasma flow. The Doppler velocities were found to be in the range from 90 to 160 km/s. The heating process has a duration which is below the SUMER exposure time of 25 s while the lifetime of the events is from 5 to 15 min. The additional check on soft X-ray Yohkoh images shows that the features most probably reach 3 MK (X-ray) temperatures. The spectroscopic analysis showed no existence of cold material during the events.

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Plasma Condensation in Coronal Loops

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Using temporal series data from the Coronal Diagnostic Spectrometer (CDS) on SOHO, we seek to investigate plasma condensation through the use of spectroscopic analysis. In a space-time (X-T) type plot we show, for a number of transition region (TR) and coronal lines, the variation of radiance with time in an off-limb loop system. Noting a number of pixels where the radiance shows a sharp jump in value for the TR lines and a corresponding sharp decrease for the coronal lines, we investigate further and plot the radiance and velocity for these pixels as a function of time. Using standard Fourier techniques, together with a pre-whitening method, we measure all statistically significant frequencies present in the time series so created. We find that, for the cooler lines of He I 584A and O V 629A there are sharp increases in radiance, accompanied by large blueshifted velocities. In the case of O V there is then a substantial rebound to redshifted velocities when the strong brightening fades. The sharp increase in radiance and blueshifted velocity in the cooler lines is accompanied by a corresponding decrease in the radiance of the coronal lines (Mg X 624A, Fe XVI 360A, Si XII 520A), but with no corresponding change in their velocity values implying an evacuation of plasma.

From the Fourier analysis, evidence is found for a possible 1st and 2nd harmonic in the He I and O V lines, indicative of standing waves in loops. We conclude that what we are seeing is the first spectroscopic evidence of plasma condensation taking place in coronal loops.

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Global Magnetic Field of the Sun as a Star and of Convective Stars

The report is dedicated to the memory of Andrew Severny.

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In terms of the Babcock and Leighton phenomenological magneto-kinematic model of the solar cycle and in terms of standard α-Ω dynamo theory, there are only two main components of large-scale magnetic field on the Sun: toroidal magnetic field and poloidal field. The first results of the magnetic field measurements of the Sun as a star were published by A. Severny, and named as General Magnetic Field (GMF) of the Sun as a Star. What is the origin of the GMF?
Using frequencies $P_1 = 26.929 \pm 0.015$ d and $P_2 = 27.144 \pm 0.015$ d, we can obtain main periods in the power spectrum for the GMF of the Sun as a star, including the period of the activity cycle. One of the initial periods is due to a rigid rotation of the radiative zone, and the second one is produced by differential rotation of the Sun's top layer. The Origin Magnetic Field of the Sun's radiative zone is captured by moving matter and transported up to the surface, where a beating of two main frequencies produces the observed picture.
The presence of weak general magnetic field (up to some dozen Gauss) for 21 convective stars (F9-M3 spectral types and I-V luminosity classes) is detected nowadays. For two solar-like stars, variations of the GMF as a function of the stellar rotation has been determined: for the more active and younger star ξ Boo A (G8 V) with $P_{rot} = 6.198$ d, and for the older solar-like star 61 Cyg A (K5 V) with $P_{rot} = 36.617$ d. For ξ Boo A, GMF variations as a function of rotational period were confirmed using the MuSiCoS Stokesmeter in 2003. The Crimea curve (1990-1999) shows domination of the dipole component contrary to the MuSiCoS curve for 2003, which demonstrates the presence of quadrupole component. An existence of the GMF on convective stars with vigorous convective envelopes confirms a hypothesis that the GMF is a real phenomenon.
GMF reflects properties of a stationary global magnetic field of the Sun's (convective star's) radiative interior on its surface, and there appears to be the third large-scale component of the magnetic field.

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A Cross-Match of 2MASS and SDSS: Newly-Found L and T Dwarfs and an Estimate of the Space Densitfy of T Dwarfs

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We report new L and T dwarfs found in a cross-match of the SDSS Data Release 1 and 2MASS. Our simultaneous search of the two databases effectively allows us to relax the criteria for object detection in either survey and to explore the combined databases to a greater completeness level. We find two new T dwarfs in addition to the 13 already known in the SDSS DR1 footprint. We also identify 22 new candidate and bona-fide L dwarfs, including a new young L2 dwarf and a peculiar L2 dwarf with unusually blue near-IR colors—potentially the result of mildly sub-solar metallicity. These discoveries underscore the utility of simultaneous database cross-correlation in searching for rare objects. Our cross-match completes the census of T dwarfs within the joint SDSS and 2MASS flux limits to the ≈97% level. Hence, we are able to accurately infer the space density of T dwarfs. We employ Monte Carlo tools to simulate the observed population of SDSS DR1 T dwarfs with 2MASS counterparts and find that the space density of T0–T8 dwarf systems is $0.0070^{+0.0032}_{-0.0030}$ pc^{-3} (95% confidence interval), i.e., about one per 140 pc^3. Compared to predictions for the T dwarf space density that depend on various assumptions for the sub-stellar mass function, this result is most consistent with models that assume a flat sub-stellar mass function $dN/dM \propto M^{0.0}$. No >T8 dwarfs were discovered in the present cross-match, though less than one was expected in the limited area (2099 deg^2) of SDSS DR1.

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Detection of Strong Activity in the Eclipsing Binary Brown Dwarf 2MASS J05352184−0546085 – A Possible Explanation for the Temperature Reversal

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We show high resolution spectra of the eclipsing brown dwarf binary 2MASS J05352184−0546085 taken at the two opposite radial velocity maxima. Comparisons of the TiO bands to model and template spectra are fully consistent with the temperatures previously derived for this system. In particular, the reversal of temperatures with mass – in which the higher-mass primary is cooler than its companion – is confirmed. We measure the projected rotation velocities of the compononents; the primary is rotating at least twice as rapidly as the secondary. At the two radial velocity maxima, Hα emission lines of both components stick out to either sides of the Hα central wavelength, which is dominated by nebula emission. This enables us to model the individual Hα lines of the primary and the secondary. We find that the Hα emission from the primary is at least 7 times stronger than the emission from the secondary. We conclude that the temperature reversal is very likely due to strong magnetic fields inhibiting convection on the primary.

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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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