COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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TABLE OF CONTENTS

Stellar Abstracts 1
Solar Abstracts 4
Abstract Guidelines 5

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Stellar Abstracts

The Chemical Composition of α Cen AB Revisited

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The two solar-like stars α Cen A and B have long served as cornerstones for stellar physics in virtue of their immediate proximity, association in a visual binary, and masses that bracket that of the Sun. The recent detection of a terrestrial planet in the cool, suspected tertiary Proxima Cen now makes the system also of prime interest in the context of planetary studies. It is therefore of fundamental importance to tightly constrain the properties of the individual stellar components. We present a fully self-consistent, line-by-line differential abundance analysis of α Cen AB based on high-quality HARPS data. Various line lists are used and analysis strategies implemented to improve the reliability of the results. Abundances of 21 species with a typical precision of 0.02-0.03 dex are reported. We find that the chemical composition of the two stars is not scaled solar (e.g. Na and Ni excess, depletion of neutron-capture elements), but that their patterns are strikingly similar, with a mean abundance difference (A – B) with respect to hydrogen of -0.01 ± 0.04 dex. Much of the scatter may be ascribed to physical effects that are not fully removed through a differential analysis because of the mismatch in parameters between the two components. We derive an age for the system from abundance indicators (e.g. [Y/Mg] and [Y/Al]) that is slightly larger than solar and in agreement with most asteroseismic results. Assuming coeval formation for the three components belonging to the system, this implies an age of about ∼6 Gyrs for the M dwarf hosting the terrestrial planet Proxima Cen b. After correction for Galactic chemical evolution effects, we find a trend between the abundance ratios and condensation temperature in α Cen A akin to that of the Sun. However, taking this finding as evidence for the sequestration of rocky material locked up in planets may be premature given that a clear link between the two phenomena remains to be established. The similarity between the abundance pattern of the binary components argues against the swallowing of a massive planet by one of the stars after the convective zones have shrunk to their present-day sizes. (→ cont.)

Accepted by A&A

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Double-Dipping: A New Relation between Stellar Rotation and Starspot Activity

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We report the discovery of a new relationship between a simple morphological characteristic of light curves produced by starspots and stellar rotation periods. The characteristic we examine is whether the light curve exhibits one dip or two during a single rotation. We analyze thousands of Kepler light curves of main sequence stars from 3200-6200K. Almost all the stars exhibit segments of their light curve that contain either single or double dip segments (very few have more than two significant dips per rotation). We define a variable, the "single/double ratio" (SDR) that expresses the ratio of the time spent in single mode to the time spent in double mode. Unexpectedly, there is a strong relationship between the SDR and the stellar rotation period, in the sense that longer periods come with a larger fraction of double segments. Even more unexpectedly, the slopes of the SDR-Period relations are a clear function of stellar temperature. We also show that the relationships of spot variability amplitude (R_{var}) to rotation period have similar levels of scatter, slopes, and dependence on temperature as the SDR-Period relations. Finally, the median R_{var} of single segments tends to be about twice that of double segments in a given light curve. We offer some tentative interpretations of these new results in terms of starspot coverage and lifetimes. It will be fruitful to look further into this novel "rotation-activity" relation, and better understand what information these aspects of light curve morphology bring to our knowledge of stellar magnetic activity.

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For preprints via WWW: https://arxiv.org/abs/1805.04587

Spatially Resolved Spectroscopy Across Stellar Surfaces III. Photospheric Fe I Lines Across HD 189733A (K1V)

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Spectroscopy across spatially resolved stellar surfaces reveals spectral line profiles free from rotational broadening, whose gradual changes from disk center toward the stellar limb reflect an atmospheric fine structure that is possible to model by 3-D hydrodynamics. Previous studies of photospheric spectral lines across stellar disks exist for the Sun and HD 209458 (G0 V) and are now extended to the planet-hosting HD 189733A to sample a cooler K-type star and explore the future potential of the method. During exoplanet transit, stellar surface portions successively become hidden and differential spectroscopy between various transit phases uncovers spectra of small surface segments temporarily hidden behind the planet. The method was elaborated in Paper I, in which observable signatures were predicted quantitatively from hydrodynamic simulations. From observations of HD 189733A with the ESO HARPS spectrometer at $\lambda/\Delta\lambda \sim$115,000, profiles for stronger and weaker Fe I lines are retrieved at several center-to-limb positions, reaching adequate S/N after averaging over numerous similar lines. Retrieved line profile widths and depths are compared to synthetic ones from models with parameters bracketing those of the target star and are found to be consistent with 3-D simulations. Center-to-limb changes strongly depend on the surface granulation structure and much greater line-width variation is predicted in hotter F-type stars with vigorous granulation than in cooler K-types. Such parameters, obtained from fits to full line profiles, are realistic to retrieve for brighter planet-hosting stars, while their hydrodynamic modeling offers previously unexplored diagnostics for stellar atmospheric fine structure and 3-D line formation. Precise modeling may be required in searches for Earth-analog exoplanets around K-type stars, whose more tranquil surface granulation and lower ensuing microvariability may enable such detections.

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For preprints via WWW: https://arxiv.org/abs/1806.00012

Finding Flares in Kepler Data Using Machine Learning Tools

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Archives of long photometric surveys, like the Kepler database, are a gold mine for studying flares. However, identifying them is a complex task; while in the case of single-target observations it can be easily done manually by visual inspection, this is nearly impossible for years-long time series for several thousand targets. Although there exist automated methods for this task, several problems are difficult (or impossible) to overcome with traditional fitting and analysis approaches. We introduce a code for identifying and analyzing flares based on machine learning methods, which are intrinsically adept at handling such data sets. We used the RANSAC (RANdom SAmple Consensus) algorithm to model light curves, as it yields robust fits even in case of several outliers, like flares. The light curve is divided into search windows, approximately in the order of the stellar rotation period. This search window is shifted over the data set, and a voting system is used to keep false positives to a minimum: only those flare candidate points are kept that were identified in several windows as a flare. The code was tested on the K2 observations of the TRAPPIST-1, and on the long cadence data of KIC 1722506. The detected flare events and flare energies are consistent with earlier results from manual inspections.

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For preprints via WWW: https://arxiv.org/pdf/1806.00334.pdf

On the Use of Gaia Magnitudes and New Tables of Bolometric Corrections

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The availability of reliable bolometric corrections and reddening estimates, rather than the quality of parallaxes will be one of the main limiting factors in determining the luminosities of a large fraction of *Gaia* stars. With this goal in mind, we provide *Gaia* $G_{\rm BP}$, G, and $G_{\rm RP}$ synthetic photometry for the entire MARCS grid, and test the performance of our synthetic colours and bolometric corrections against space-borne absolute spectrophotometry. We find indication of a magnitude-dependent offset in *Gaia* DR2 G magnitudes, which must be taken into account in high accuracy investigations. Our interpolation routines are easily used to derive bolometric corrections at desired stellar parameters, and to explore the dependence of *Gaia* photometry on $T_{\rm eff}$, $\log g$, [Fe/H], [α/Fe] and $E(B-V)$. *Gaia* colours for the Sun and Vega, and $T_{\rm eff}$-dependent extinction coefficients, are also provided.

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For preprints via WWW: https://arxiv.org/abs/1806.01953
Tables and interpolation routines at:
https://github.com/casaluca/bolometric-corrections

Explicit IMF B_y-dependence in High-latitude Geomagnetic activity

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The interaction of the solar wind with the Earth's magnetic field produces geomagnetic activity, which is critically dependent on the orientation of the interplanetary magnetic field (IMF). Most solar wind coupling functions quantify this dependence on the IMF orientation with the so-called IMF clock angle in a way, which is symmetric with respect to the sign of the B_y component. However, recent studies have suggested that the sign of B_y is an additional, independent driver of high-latitude geomagnetic activity, leading to higher (weaker) geomagnetic activity in Northern Hemisphere (NH) winter for $B_y > 0$ ($B_y < 0$). In this paper we quantify the size of this explicit B_y-effect with respect to the solar wind coupling function, both for Northern and Southern high-latitude geomagnetic activity. We show that high-latitude geomagnetic activity is significantly (by about 40-50%) suppressed for $B_y < 0$ in NH winter and for $B_y > 0$ in SH winter. When averaged over all months, high-latitude geomagnetic activity in NH is about 12% weaker for $B_y < 0$ than for $B_y > 0$. The B_y-effect affects the westward electrojet strongly but hardly at all the eastward electrojet. We also show that the suppression of the westward electrojet in NH during $B_y < 0$ maximizes when the Earth's dipole axis points towards the night sector, i.e., when the auroral region is maximally in darkness.

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For preprints via WWW: https://arxiv.org/abs/1805.10699

Cyclic Changes of the Sun's Seismic Radius

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The questions whether the Sun shrinks with the solar activity and what causes this have been a subject of debate. Helioseismology provides means to measure with high precision the radial displacement of subsurface layers, co-called "seismic radius", through analysis of oscillation frequencies of surface gravity (f) modes. Here, we present results of a new analysis of twenty one years of helioseismology data from two space missions, Solar and Heliospheric Observatory (SoHO) and Solar Dynamics Observatory (SDO), which allow us to resolve previous uncertainties and compare variations of the seismic radius in two solar cycles. After removing the f-mode frequency changes associated with the surface activity we find that the mean seismic radius is reduced by 1-2 km during the solar maxima, and that most significant variations of the solar radius occur beneath the visible surface of the Sun at the depth of about 5 Mm, where the radius is reduced by 5-8 km. These variations can be interpreted as changes in the solar subsurface structure caused by predominately vertical 10 kG magnetic field. .

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For preprints via WWW: https://arxiv.org/abs/1805.09385 , and
https://www.sciencenews.org/article/sun-shrinks-teensy-bit-when-its-feeling-active?tgt=nr

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. Abstracts for conference proceedings articles are *not* posted in *COOLNEWS*. The subject matter should pertain directly to cool stars (spectral types F,G,K,M or L), substellar objects, or the sun. Both theoretical and observational abstracts are appropriate.

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 bimonthly call for abstracts will be issued. 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` .

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