# *COOLNEWS*

**A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN**

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## *Coolnews on the Web*

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## *Stellar Abstracts*

### Orbitally Modulated Photoexcited Si I Emission in the Eclipsing Composite-spectrum Binary $\zeta$ Aurigae


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We examine the little-known phenomenon of orbitally modulated Si I emission at $\lambda\,3905.523$Å and $\lambda\,4102.936$Å in composite-spectrum binaries, with specific reference to $\zeta$ Aurigae (K4 Ib + B5 V). The emission is detected in the isolated spectrum of the B-type dwarf secondary, and while $\lambda\,4102$Å is heavily blended with H$\delta$, $\lambda\,3905$Å falls in the B-stars featureless continuum. The narrowness of the emission ($v_{turb} \simeq 6\,\mathrm{km\,s^{-1}}$) demonstrates that it originates in the upper photosphere or deep chromosphere of the K star primary. We propose that photoexcitation by the hot stars UV continuum, followed by recombination and cascades, leads to resonant scattering and subsequent pumping of lower opacity transitions in the singlet and triplet systems of Si I. This process channels the UV continuum into select narrow emission lines. We have also identified weaker photoexcited emission of Fe II at $\lambda\,3938.289$Å. The strengths, positions, and widths of the $\lambda\,3905$Å emission line vary with orbital phase owing to changes in the dilution of the irradiating flux and in the geometrical aspect of the irradiated hemisphere. Utilizing the inherent spatial resolution provided by the illuminated patch, and assuming that the K star is spherical with isotropic emission, yields $v \sin i \sim 5.7\,\mathrm{km\,s^{-1}}$. Evidence of tidal distortion was deduced from the timing of the rapidly rising phase of the emission just after periastron. Increasing the diagnostic potential requires radiative transfer modelling of the formation and centre-to-limb variation of the emission.

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## Near Infrared Spectroscopy of M Dwarfs. III. Carbon and Oxygen Abundances in Late M Dwarfs Including the Dusty Rapid Rotator 2MASSI J1835379+325954

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Carbon and oxygen abundances of eight late M dwarfs are determined based on the near infrared spectra of medium resolution ($R = \lambda/\Delta\lambda \approx 20000$). In late M dwarfs, dust forms in their photospheres for $T_{\rm eff}$ below about 2600 K, and this case applies to the M8.5 dwarf 2MASSI J1835379+325954 (hereafter 2MASS 1835+32) in our sample. Other seven objects with $T_{\rm eff}$ above 2600 K are analyzed with the dust-free models and these late M dwarfs are analyzed as the early and middle M dwarfs without any additional problems. For the case of 2MASS 1835+32 whose $T_{\rm eff}$ is 2275 K, the surface temperature increases by about 600 K by the backwarming effect of the dust grains, mainly composed of iron grains, and carbon and oxygen abundances based on the dusty model increase by 0.25 and 0.15 dex, respectively, compared to those based on the model photosphere neglecting the dust formation. Once dust forms in the photosphere, the dust works as a kind of thermostat and temperatures of the surface layers remain nearly the same as the condensation temperatures of the iron grains. For this reason, the temperatures of the surface layers of the dusty dwarfs are relatively insensitive to the fundamental parameters including $T_{\rm eff}$.

It is known that 2MASS 1835+32 is a rapid rotator, for which it is generally thought that the EWs remain unchanged by the rotational broadening. This is, however, true only when the true continuum is well defined. Otherwise, the pseudo-continuum level depends on the rotational velocity and hence the EWs as well. For this reason, the derived abundances depend on the rotational velocity assumed: For the values of $V_{\rm rot}\sin i = 37.6$ and 44.0 km s$^{-1}$ available in the literature, the derived carbon and oxygen abundances differ by 0.23 and 0.14 dex, respectively, and we find that the higher $V_{\rm rot}\sin i$ provides a better account of the observed spectrum.

The resulting carbon and oxygen abundances in eight late M dwarfs show no systematic difference from our results for early and middle M dwarfs, and confirm the higher $A_{\rm O}/A_{\rm C}$ ratio at the lower metallicity. Since the insensitivity of CO and $H_2O$ abundances to the uncertainties of the model photospheres is even applies better to the late M dwarfs, CO and $H_2O$ remain as excellent abundance indicators of carbon and oxygen, respectively, in late M dwarfs, except for additional uncertainty due to the complexity associated with the dust formation in the case of the latest M dwarfs.

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## FK Comae Berenices, King of Spin: The COCOA-PUFS$^\star$ Project

$^\star$**CO**ordinated **C**ampaign of **O**bservations and **A**nalysis, **P**hotosphere to **U**pper Atmosphere, of a **F**ast-rotating **S**tar

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COCOA-PUFS is an energy-diverse, time-domain study of the ultra-fast spinning, heavily spotted, yellow giant FK Comae Berenices (FK Com: HD117555; G4 III). This single star is thought to be a recent binary merger, and is exceptionally active by measure of its intense ultraviolet (UV) and X-ray emissions, and proclivity to flare. COCOA-PUFS was carried out with Hubble Space Telescope (*HST*) in the UV (1200–3000 Å), using mainly its high-performance Cosmic Origins Spectrograph (COS), but also high-precision Space Telescope Imaging Spectrograph (STIS); *Chandra* X-ray Observatory in the soft X-rays (0.5–10 keV), utilizing its High-Energy Transmission Grating Spectrometer

(HETGS); together with supporting photometry and spectropolarimetry in the visible from the ground. This is an introductory report on the project.

FK Com displayed variability on a wide range of time scales, over all wavelengths, during the week-long main campaign, including a large X-ray flare; "super-rotational broadening" of the far-ultraviolet (FUV) "hot-lines" (e.g., Si IV 1393 Å; $8\times10^4$ K) together with chromospheric Mg II 2800 Å and C II 1335 Å ($1–3\times10^4$ K); large Doppler swings suggestive of bright regions alternately on advancing and retreating limbs of the star; and substantial redshifts of the epoch-average emission profiles. These behaviors paint a picture of a highly extended, dynamic, hot ($\sim 10$ MK) coronal magnetosphere around the star, threaded by cooler structures perhaps analogous to solar prominences, and replenished continually by surface activity and flares. Suppression of angular momentum loss by the confining magnetosphere could temporarily postpone the inevitable stellar spindown, thereby lengthening this highly volatile stage of coronal evolution.

Accepted by ApJS

*For preprint via astro-ph*: http://arxiv.org/abs/1601.03305

# *Solar Abstracts*

## Development of Active Regions: Flows, Magnetic-field Patterns and Bordering Effect

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A qualitative analysis is given to the data on the full magnetic and velocity vector fields in a growing sunspot group, recorded nearly simultaneously with the *Solar Optical Telescope* on the *Hinode* satellite. Observations of a young bipolar subregion developing within AR 11313 were carried out on 9-10 October 2011. Our aim was to form an idea about the consistency of the observed pattern with the well-known rising-tube model of the formation of bipolar active regions and sunspot groups. We find from our magnetograms that the distributions of the vertical [$B_\mathrm{v}$] and the horizontal [$B_\mathrm{h}$] component of the magnetic field over the area of the magnetic subregion are spatially well correlated; in contrast, the rise of a flux-tube loop would result in a qualitatively different pattern, with the maxima of the two magnetic-field components spatially separated: the vertical field would be the strongest where either spot emerges, while the maximum horizontal-field strengths would be reached in between them. A specific feature, which we call the *bordering effect*, is revealed: some local extrema of $B_\mathrm{v}$ are bordered with areas of locally enhanced $B_\mathrm{h}$. This effect suggests a fountainlike spatial structure of the magnetic field near the $B_\mathrm{v}$ extrema, which is also hardly compatible with the emergence of a flux-tube loop. The vertical-velocity field in the area of the developing active subregion does not exhibit any upflow on the scale of the whole subregion, which should be related to the rising-tube process. Thus, our observational data can hardly be interpreted in the framework of the rising-tube model.

Accepted by Solar Physics

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*For preprints via WWW*: http://arxiv.org/abs/1506.01848

## A Two-wave Dynamo Model by Zharkova et al. (2015) Disagrees with Data on Long-term Solar Variability

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A two-wave dynamo model was recently proposed by Zharkova et al. (2015, Zh15 henceforth), which aims at long-term predictions of solar activity for millennia ahead and backwards. Here we confront the backward model predictions for the last 800 years with known variability of solar activity, using both direct sunspot observations since 1610 and reconstructions based on cosmogenic radionuclide data. We show that the Zh15 model fails to reproduce the well-

established features of the solar activity evolution during the last millennium. This means that the predictive part for the future is not reliable either.

Submitted to Sci. Rep.

*For preprints contact*: ilya.usoskin@oulu.fi

*For preprints via WWW*: http://arxiv.org/abs/1512.05516

## A New Calibrated Sunspot Group Series Since 1749: Statistics of Active Day Fractions

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Although the sunspot-number series have existed since the mid-19th century, they are still the subject of intense debate, with the largest uncertainty being related to the "calibration" of the visual acuity of individual observers in the past. Usually a daisy-chain regression method is applied to inter-calibrate the observers which may lead to significant bias and error accumulation. Here we present a novel method to calibrate the visual acuity of the key observers to the reference data set of Royal Greenwich Observatory sunspot groups for the period 1900 – 1976, using the statistics of the active-day fraction. For each observer we independently evaluate their observational thresholds [$S_S$] defined such that the observer is assumed to miss all of the groups with an area smaller than $S_S$ and report all the groups larger than $S_S$. Next, using a Monte-Carlo method we construct, from the reference data set, a correction matrix for each observer. The correction matrices are significantly non-linear and cannot be approximated by a linear regression or proportionality. We emphasize that corrections based on a linear proportionality between annually averaged data lead to serious biases and distortions of the data. The correction matrices are applied to the original sunspot group records reported by the observers for each day, and finally the composite corrected series is produced for the period since 1748. The corrected series is provided as supplementary material in electronic form and displays secular minima around 1800 (Dalton minimum) and 1900 (Gleissberg minimum), as well as the Modern grand maximum of activity in the second half of the 20th century. The uniqueness of the grand maximum is confirmed for the last 250 years. It is shown that the adoption of a linear relationship between the data of Wolf and Wolfer results in grossly inflated group numbers in the 18th and 19th centuries in some reconstructions.

Accepted by Solar Physics

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*For preprints via WWW*: http://link.springer.com/article/10.1007/s11207-015-0838-1

*Editor's Note:* The abstracts below are being cross-listed with the *Star Formation Newsletter.*

## Physical Parameters and Long-term Photometric Variability of V1481 Ori, a SB2 Member of Orion Nebula Cluster with an Accreting Component

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We present the results of our analysis on V1481 Ori (JW 239), a young SB2 in the Orion Nebula Cluster with a circumbinary disc accreting on the lower-mass component. The analysis is based on high-resolution spectroscopic data and high-quality photometric time series about 20-yr long. Thanks to the spectroscopy, we confirm the binary nature of this system consisting of M3 + M4 components and derive the mass ratio $M_B/M_A = 0.54$, a variable luminosity ratio $L_B/L_A = 0.68$–$0.94$, and an orbital period $P_{orb} = 4.433$ d. The photometric data allowed us to measure the rotation periods of the two components $P_{phot} = 4.4351$ d and they are found to be synchronized with the orbital period. The simultaneous modeling of V-, I-band, and radial velocity curves in the 2005 season suggests that the variability is dominated by one hot spot on the secondary component covering at least $\sim$3.5% of the stellar surface and about 420 K hotter than the unperturbed photosphere. Such a spot may originate from the material of the circumbinary disc accreting onto the secondary component. We also detect an apparent 6-yr periodic variation in the position of this hot spot, which is inferred from the phase migration of the light curve maximum, which we interpret as due to either the presence of surface differential rotation as large as 0.065%, a value compatible with the fully convective components, or to a periodic exchange of angular momentum between the disc and the star, which implies a minimum magnetic field strength of 650 G at the stellar surface.

Accepted by MNRAS

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*Upcoming Meeting*

# Space Climate School and Space Climate-6 Symposium

## 30 March - 7 April 2016

## Levi, Finland

SECOND ANNOUNCEMENT

Dear Colleagues and Friends!

We have the great pleasure to invite you to *Space Climate School* on 30 March - 3 April, 2016 and *Space Climate-6 Symposium* on 4-7 April, 2016,

in the Hotel Hullu Poro (Crazy Reindeer) at Levi, Finnish Lapland (about 68N lat).

*Space Climate School* includes lectures and hands-on workshops on several important long-term datasets of solar, space, geomagnetic and climate observations, and their analysis using data mining, pattern recognition, time series and statistical methods. School lecturers include (all confirmed) Rainer Arlt, Juan Banda, David Berghmans, Achim Drebs, Ilaria Ermolli, Magnar Gullikstad Johnsen, Juha Karvanen, Greg Kopp, Natalie Krivova, Ari Laaksonen, Ken McCracken, Aimee Norton, Jaan Pelt, and Alexey Pevtsov.

Note that **students** selected to *Space Climate School* will have **free housing (and no fee)**.

*Space Climate-6 Symposium* includes Sessions on: Solar dynamo as a driver of space climate, Long-term solar activity, Asymmetric Sun, Extreme events in the Sun-Earth system, Solar corona - solar wind and HMF, Solar wind-Magnetosphere-Ionosphere interaction, Solar Influence on atmosphere and climate, and a Topical Debate on long-term sunspot activity.

Confirmed invited speakers include: Dan Baker, Joe Borovsky, Frederic Clette, Ingrid Cnossen, Nat Gopalswamy, Hugh Hudson, Sheila Kirkwood, Natalie Krivova, Jon Linker, Ken McCracken, Florian Mekhaldi, Mari Paz Miralles, Martin Mlynczak, Ralph Neuhaeuser, Matt Owens, Dario Passos, Gordon Petrie, Alexei Pevtsov, Tuija Pulkkinen, Eugene Rozanov, Alexander Ruzmaikin, Kazunari Shibata, Jose Vaquero, Pekka Verronen, Jrn Warnecke, and Valentina Zharkova

Important deadlines:

31 Dec 2015 School application
15 Jan 2016 Symposium early bird registration
31 Jan 2016 Hotel accommodation at special price
31 Jan 2016 Symposium abstract submission

For more information, see the symposium website:
http://www.spaceclimate.fi

For questions, contact: spaceclimate@spaceclimate.fi

Welcome to Space Climate School and Space Climate-6 Symposium in Levi!

Sincerely Yours,

Kalevi Mursula (SOC chair), Ilya Usoskin (SOC vice-chair), Timo Asikainen (LOC chair), Ilpo Virtanen (LOC vice-chair)

# *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 .`

*** Please send abstracts in the body of the message and *not* as attachments.***