COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 193 — Sept. - Oct. 2014 Editor: Steve Skinner (coolnews@jila.colorado.edu)

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Stellar Abstracts

Systematic Trend of Water Vapour Absorption in Red Giant Atmospheres Revealed by High Resolution TEXES 12 Micron Spectra

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The structures of the outer atmospheres of red giants are very complex. The notion of large optically thick molecular spheres around the stars (MOLspheres) has been invoked in order to explain e.g. spectro-interferometric observations. However, high-resolution spectra in the mid-IR do not easily fit into this picture. They rule out any large sphere of water vapour in LTE surrounding red giants. Our aim here is to investigate high-resolution, mid-infrared spectra for a range of red giants, from early-K to mid M. We have recorded 12 microns spectra of 10 well-studied bright red giants, with TEXES on the IRTF. We find that all giants in our study cooler than 4300 K, spanning a range of effective temperatures, show water absorption lines stronger than expected. The strengths of the lines vary smoothly with spectral type. We identify several spectral features in the wavelength region that undoubtedly are formed in the photosphere. From a study of water-line ratios of the stars, we find that the excitation temperatures, in the line-forming regions, are several hundred Kelvin lower than expected from a classical photospheric model. This could either be due to an actually lower temperature structure in the outer regions of the photospheres caused by, for example, extra cooling, or due to non-LTE level populations, affecting the source function and line opacities. We have demonstrated that these diagnostically interesting water lines are a general feature of red giants across spectral types, and we argue for a general explanation of their formation rather than explanations requiring specific properties. Since the water lines are neither weak (filled in by emission) nor appear in emission, as predicted by LTE MOLsphere models in their simplest forms, the evidence for the existence of such large optically-thick, molecular spheres enshrouding the stars is weakened. (abbreviated)

Accepted by A&A

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New Fe I Level Energies and Line Identifications from Stellar Spectra

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The spectrum of the Fe I atom is critical to many areas of astrophysics and beyond. Measurements of the energies of its high-lying levels remain woefully incomplete, however, despite extensive laboratory and solar analysis. In this work we use high-resolution archival absorption-line ultraviolet and optical spectra of stars, whose warm temperatures favor moderate Fe I excitation. We derive the energy for a particular upper level in Kurucz's semiempirical calculations by adopting a trial value that yields the same wavelength for a given line predicted to be about strong as that of a strong unidentified spectral line observed in the stellar spectra, then checking the new wavelengths of other strong predicted transitions that share the same upper level for coincidence with other strong observed unidentified lines. To date this analysis has provided the upper energies of 66 Fe I levels. Many new level energies are higher than those accessible to laboratory experiments; several exceed the Fe I ionization energy. These levels provide new identifications for over two thousand potentially detectable lines. Almost all of the new levels of odd parity include UV lines that were detected but unclassified in laboratory Fe I absorption spectra, providing an external check on the energy values. We motivate and present the procedure, provide the resulting new level energies and their uncertainties, list all the potentially detectable UV and optical new Fe I line identifications and their gf-values, point out new lines of astrophysical interest, and discuss the prospects for additional Fe I energy-level determinations.

Accepted by ApJ Supp.

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For preprints via WWW: http://arxiv.org/abs/1406.0933

The Origin of the Metal-Poor Common Proper Motion Pair HD 134439/134440: Insights from New Elemental Abundances

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The low [α/Fe] ratio in the metal-poor ([Fe/H]~ -1.50) common proper motion pair HD 134439 and HD 134440 has been variously attributed to chemical evolution in an extragalactic environment with an irregular star formation history, planetessimal accretion, and formation in an environment with an unusually high dust-to-gas ratio. We explore these various putative origins using CNO, Be, Ag, and Eu abundances derived from high-resolution near-UV Keck/HIRES spectroscopy. While we confirm a previously suggested correlation between elemental abundance ratios and condensation temperature at the 95% confidence level, these ratios lie within the continuum of values manifested by extant dSph data. We argue that the most plausible origin of our stars' distinctive abundance distribution relative to the Galactic halo field is formation in an environment chemically dominated by products of Type II SN of low progenitor mass; such a progenitor mass bias has been previously suggested as an explanation of low α-element ratios of dSph stars. The proper motion pair's heavy-to-light n-capture element ratio, which is $\geq 0.3 - 0.5$ dex lower than in the Galactic halo field and dSph stars, is discussed in the context of the truncated r-process, phenomenlogical n-capture production models, and α-rich freezeout in a high neutron excess environment; the latter simultaneously provides an attractive explanation of the difference in [Ca,Ti/O,Mg,Si] ratio in HD 134439/134440 compared to *in situ*

dSph stars.

Accepted by PASP

For preprints via WWW: http://arxiv.org/abs/1410.8646

The Far-Ultraviolet Ups and Downs of Alpha Centauri

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Four years (2010–2014) of semiannual pointings by *Hubble* Space Telescope Imaging Spectrograph (STIS) on nearby Alpha Centauri have yielded a detailed time history of far-ultraviolet (FUV: 1150–1700 Å) emissions of the solar-like primary (A: G2 V) and the cooler, but more active, secondary (B: K1 V). This period saw A climbing out of a prolonged coronal X-ray minimum, as documented contemporaneously by *Chandra,* while B was rising to, then falling from, a peak of its long-term ($\sim$ 8 yr) starspot cycle. The FUV fluxes of the primary were steady over most of the STIS period, although the [Fe XII] λ1242 coronal forbidden line ($T \sim 1.5$ MK) partly mirrored the slowly rising X-ray fluxes. The FUV emissions of the secondary more closely tracked the rise and fall of its coronal luminosities, especially the "hot lines" like Si IV, C IV, and N V ($T \sim 0.8$–2×10^5 K), and coronal [Fe XII] itself. The hot lines of both stars were systematically redshifted, relative to narrow chromospheric emissions, by several km s^{-1}, showing little change in amplitude over the 4-year period; especially for α Cen B, despite the significant evolution of its coronal activity. Further, the hot lines of both stars, individually and epoch-averaged, displayed non-Gaussian shapes, which most trivially could be decomposed into two components, one narrow (FWHM $\sim$ 25–45 km s^{-1}), the other broad (60–80 km s^{-1}). The bimodal Gaussian strategy had been applied previously to the α Cen stars, but this was the first opportunity to evaluate any time dependence. In fact, not much variation of the component properties was seen, even over the major cycle changes of B. Curiously, the line fluxes were about equally divided between the narrow and broad components for both stars. The fact that there is minimal activity-dependence of the narrow/broad flux partition, as well as densities derived from O IV] line ratios, either during the cycle evolution of B, or between A and B, suggests that there is a dominant "quantum" of FUV surface activity that is relatively unchanged during the cycle, aside from the fractional area covered.

Accepted by AJ

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For preprints via WWW: http://adsabs.harvard.edu/abs/2014arXiv1411.0038A

Discovery of a Thorne-Żytkow Object Candidate in the Small Magellanic Cloud

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Thorne-Żytkow objects (TŻOs) are a theoretical class of star in which a compact neutron star is surrounded by a large, diffuse envelope. Supergiant TŻOs are predicted to be almost identical in appearance to red supergiants (RSGs). The best features that can be used at present to distinguish TŻOs from the general RSG population are the unusually strong heavy-element and Li lines present in their spectra, products of the star's fully convective envelope linking the photosphere with the extraordinarily hot burning region in the vicinity of the neutron star core. Here we present our discovery of a TŻO candidate in the Small Magellanic Cloud. It is the first star to display the distinctive chemical profile of anomalous element enhancements thought to be unique to TŻOs. The positive detection of a TŻO will provide the first direct evidence for a completely new model of stellar interiors, a theoretically predicted fate for massive binary systems, and never-before-seen nucleosynthesis processes that would offer a new channel for Li and heavy-element production in our universe.

Accepted by MNRAS Letters

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For preprints via WWW: http://arxiv.org/abs/1406.0001

Solar Abstracts

On Magnetic Activity Band Overlap, Interaction, and the Formation of Complex Solar Active Regions

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Recent work has revealed an phenomenological picture of the how the ∼11-year sunspot cycle of Sun arises. The production and destruction of sunspots is a consequence of the latitudinal-temporal overlap and interaction of the toroidal magnetic flux systems that belong to the 22-year magnetic activity cycle and are rooted deep in the Sun's convective interior. We present a conceptually simple extension of this work, presenting a hypothesis on how complex active regions can form as a direct consequence of the intra- and extra-hemispheric interaction taking place in the solar interior. Furthermore, during specific portions of the sunspot cycle we anticipate that those complex active regions may be particular susceptible to profoundly catastrophic breakdown—producing flares and coronal mass ejections of most severe magnitude.

Accepted by ApJL

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For preprints via WWW: http://arxiv.org/abs/1410.6411

Bright Hot Impacts by Erupted Fragments Falling Back on the Sun: UV Redshifts in Stellar Accretion

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A solar eruption after a flare on 7 Jun 2011 produced EUV-bright impacts of fallbacks far from the eruption site, observed with the Solar Dynamics Observatory. These impacts can be taken as a template for the impact of stellar accretion flows. Broad red-shifted UV lines have been commonly observed in young accreting stars. Here we study the emission from the impacts in the Atmospheric Imaging Assembly's UV channels and compare the inferred velocity distribution to stellar observations. We model the impacts with 2D hydrodynamic simulations. We find that the localised UV 1600Å emission and its timing with respect to the EUV emission can be explained by the impact of a cloud of fragments. The first impacts produce strong initial upflows. The following fragments are hit and shocked by these upflows. The UV emission comes mostly from the shocked front shell of the fragments while they are still falling, and is therefore redshifted when observed from above. The EUV emission instead continues from the hot surface layer that is fed by the impacts. Fragmented accretion can therefore explain broad redshifted UV lines (e.g. C IV 1550 Å) to speeds around 400 km/s observed in accreting young stellar objects.

Accepted by ApJ Letters

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X-ray Flare Spectra from the DIOGENESS Spectrometer and Its Concept Applied to ChemiX on the Interhelioprobe Spacecraft

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The *DIOGENESS* X-ray crystal spectrometer on the *CORONAS-F* spacecraft operated for a single month (25 August to 17 September) in 2001 but in its short lifetime obtained one hundred and forty high-resolution spectra from some eight solar flares with *GOES* importance ranging from C9 to X5. The instrument included four scanning flat crystals with wavelength ranges covering the regions of Si XIII (6.65 Å), S XV (5.04 Å), and Ca XIX (3.18 Å) X-ray lines and associated dielectronic satellites. Two crystals covering the Ca XIX lines were oriented in a "Dopplerometer" manner, i.e. such that spatial and spectral displacements both of which commonly occur in flares can be separated. We describe the *DIOGENESS* spectrometer and the spectra obtained during flares which include lines not hitherto seen from spacecraft instruments. An instrument with very similar concept is presently being built for the two Russian *Interhelioprobe* spacecraft due for launch in 2020 and 2022 that will make a near-encounter (perihelion ~ 0.3 a.u.) to the Sun in its orbit. We outline the results that are likely to be obtained.

Accepted by Solar Physics

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Low-Mass and Substellar Abstracts

Weather on Other Worlds. II. Survey Results: Spots are Ubiquitous on L and T Dwarfs

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We present results from the *Weather on Other Worlds Spitzer* Exploration Science program to investigate photometric variability in L and T dwarfs, usually attributed to patchy clouds. We surveyed 44 L3–T8 dwarfs, spanning a range of $J - K_s$ colors and surface gravities. We find that 14/23 ($61\%^{+17\%}_{-20\%}$, 95% confidence) of our single L3–L9.5 dwarfs are variable with peak-to-peak amplitudes between 0.2% and 1.5%, and 5/16 ($31\%^{+25\%}_{-17\%}$) of our single T0–T8 dwarfs are variable with amplitudes between 0.8% and 4.6%. After correcting for sensitivity, we find that $80\%^{+20\%}_{-27\%}$ of L dwarfs vary by ≥0.2%, and $36\%^{+26\%}_{-17\%}$ of T dwarfs vary by ≥0.4%. Given viewing geometry considerations, we conclude that photospheric heterogeneities causing >0.2% 3–5 μm flux variations are present on virtually all L dwarfs, and probably on most T dwarfs. A third of L dwarf variables show irregular light curves, indicating that L dwarfs may have multiple spots that evolve over a single rotation. Also, approximately a third of the periodicities are on time scales >10 h, suggesting that slowly-rotating brown dwarfs may be common. We observe an increase in the maximum amplitudes over the entire spectral type range, revealing a potential for greater temperature contrasts in T dwarfs than in L dwarfs. We find a tentative association (92% confidence) between low surface gravity and high-amplitude variability among L3–L5.5 dwarfs. Although we can not confirm whether lower gravity is also correlated with a higher incidence of variables, the result is promising for the characterization of directly imaged young extrasolar planets through variability.

Accepted by ApJ

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The Exoplanet Orbit Database II: Updates to exoplanets.org

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The Exoplanet Orbit Database (EOD) compiles orbital, transit, host star, and other parameters of robustly detected exoplanets reported in the peer-reviewed literature. The EOD can be navigated through the Exoplanet Data Explorer (EDE) Plotter and Table, available on the World Wide Web at exoplanets.org. The EOD contains data for 1492 confirmed exoplanets as of July 2014. The EOD descends from a table in Butler et al. 2002 and the Catalog of Nearby Exoplanets Butler et al. 2006, and the first complete documentation for the EOD and the EDE was presented in Wright et al. 2011. In this work, we describe our work since then. We have expanded the scope of the EOD to include secondary eclipse parameters, asymmetric uncertainties, and expanded the EDE to include the sample of over 3000 *Kepler* Objects of Interest (KOIs), and other real planets without good orbital parameters (such as many of those detected by microlensing and imaging). Users can download the latest version of the entire EOD as a single comma separated value file from the front page of exoplanets.org.

Accepted by PASP

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Solar System Science

University of Göttingen (Germany)

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Thank you very much for your consideration, Sonja Schuh

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Dr. Sonja Schuh (info@solar-system-school.de), IMPRS Scientific Coordinator

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.***