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

3D NLTE Analysis of the Most Iron-deficient Star, SMSS0313-6708

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Models of star formation in the early universe depend on the details of accretion, fragmentation and radiative feedback. Different simulations predict different initial mass functions of the first stars, ranging from predominantly low mass (0.1–10 $M_\odot$), to massive (10–100 $M_\odot$), or even supermassive (100–1000 $M_\odot$). The mass distribution of the first stars should lead to unique chemical imprints on the low-mass second and later generation metal-poor stars still in existence. The chemical composition of SMSS0313-6708, which has the lowest abundances of Ca and Fe of any star known, indicates it was enriched by a single massive supernova. However, even weak spectral lines may be affected by strong 3D and NLTE effects in metal-poor stars. If these effects are ignored or treated incorrectly, errors in the inferred abundances may significantly bias the inferred properties of the polluting supernovae. We redetermine the chemical composition of SMSS0313-6708 using 3D NLTE radiative transfer to obtain accurate abundances for Li, Na, Mg, Al, Ca and Fe. The model atoms employ realistic collisional rates, with no calibrated free parameters. We find significantly higher abundances in 3D NLTE than 1D LTE by 0.8 dex for Fe, and 0.5 dex for Mg, Al and Ca, while Li and Na are

unaffected to within 0.03 dex. In particular, our upper limit for [Fe/H] is now a factor ten larger, at [Fe/H] < -6.53 (3σ), than previous estimates based on ⟨3D⟩ NLTE (i.e., using averaged 3D models). This higher estimate is due to a conservative upper limit estimation, updated NLTE data, and 3D–⟨3D⟩ NLTE differences, all of which lead to a higher abundance determination. We find that the revised chemical composition of SMSS0313-6708 matches supernova yields for massive progenitors of 20–60 $M_\odot$ exploding with low energies (1–2×10^{51} erg), as well as progenitors of 10 $M_\odot$ with very low explosion energies ($< 10^{51}$ erg).

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For preprints via WWW: https://arxiv.org/abs/1609.07416

A Closer Look at the Alpha Persei Coronal Conundrum

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A *ROSAT* survey of the Alpha Per open cluster in 1993 detected its brightest star, mid-F supergiant α Persei: the X-ray luminosity and spectral hardness were similar to coronally active late-type dwarf members. Later, in 2010, a *Hubble* Cosmic Origins Spectrograph SNAPshot of α Per found far-ultraviolet coronal proxy Si IV unexpectedly weak. This, and a suspicious offset of the *ROSAT* source, suggested that a late-type companion might be responsible for the X-rays. Recently, a multi-faceted program tested that premise. Groundbased optical coronography, and near-UV imaging with *HST* Wide Field Camera 3, searched for any close-in faint candidate coronal objects, but without success. Then, a *Chandra* pointing found the X-ray source single and coincident with the bright star. Significantly, the Si IV emissions of α Per, in a deeper FUV spectrum collected by *HST* COS as part of the joint program, aligned well with chromospheric atomic oxygen (which must be intrinsic to the luminous star), within the context of cooler late-F and early-G supergiants, including Cepheid variables. This pointed to the X-rays as the fundamental anomaly. The over-luminous X-rays still support the case for a hyperactive dwarf secondary, albeit now spatially unresolved. However, an alternative is that α Per represents a novel class of coronal source. Resolving the first possibility now has become more difficult, because the easy solution – a well separated companion – has been eliminated. Testing the other possibility will require a broader high-energy census of the early-F supergiants.

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For preprints via WWW: https://arxiv.org/abs/1702.01310

The Rotation-Activity Correlations in K and M Dwarfs II. New Constraints on the Dynamo Mechanisms in Late-K and M Dwarfs Before and At the Transition to Complete Convection

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We study the rotation-activity correlations (RACs) in a sample stars from spectral type dK4 to dM4. We study RACs using chromospheric data and coronal data. We study the Ca II line surface fluxes-$P/\sin i$ RACs. We fit the RACs with linear homoscedastic and heteroscedastic regression models. We find that these RACs differ substantially from one spectral sub-type to another. For dM3 and dM4 stars, we find that the RACs cannot be described by a simple model, but instead that there may exist two distinct RAC behaviors for the low activity and the high activity stellar sub-samples respectively. Although these results are preliminary and will need confirmation, the data suggest that these distinct RACs may be associated with different dynamo regimes.

We also study R'_{HK} as a function of the Rossby number R_0. We find that: (i) For dK4 stars, we confirm R'_{HK} as a function of R_0 agrees well with previous results for F-G-K stars. (ii) In dK6, dM2, dM3 and dM4 stars, we find that,

at a given R_0, the values of R'_{HK} lie a factor of 3, 10, 20 and 90 respectively below the F-G-K RAC. Our results suggest a significant decrease in the efficiency of the dynamo mechanism(s) as regards chromospheric heating before and at dM3, i.e. before and at the TTCC.

We also show that the ratio of coronal heating to chromospheric heating L_X/L_{HK} increases by a factor of 100 between dK4 and dM4 stars.

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For preprints via WWW: http://arxiv.org/abs/1701.07608

SOFIA-EXES Mid-IR Observations of [Fe II] Emission from the Extended Atmosphere of Betelgeuse

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We present a NASA-DLR SOFIA-Echelon Cross Echelle Spectrograph (EXES) and NASA Infrared Telescope Facility-Texas Echelon Cross Echelle Spectrograph (TEXES) mid-IR $R \simeq 50,000$ spectral study of forbidden Fe II transitions in the early-type M supergiants, Betelgeuse (α Ori: M2 Iab) and Antares (α Sco: M1 Iab + B3 V). With EXES, we spectrally resolve the ground term [Fe II] 25.99 μm ($a^6D_{J=7/2-9/2}$: $E_{up} = 554\,$K) emission from Betelgeuse. We find a small centroid blueshift of $1.9 \pm 0.4\,$kms^{-1} that is a significant fraction (20%) of the current epoch wind speed, with a FWHM of $14.3 \pm 0.1\,$km s^{-1}. The TEXES observations of [Fe II] 17.94 μm ($a^4F_{J=7/2-9/2}$: $E_{up} = 3,496\,$K) show a broader FWHM of $19.1 \pm 0.2\,$km s^{-1}, consistent with previous observations, and a small redshift of $1.6 \pm 0.6\,$kms^{-1} with respect to the adopted stellar center-of-mass velocity of $V_{CoM} = 20.9 \pm 0.3\,$km s^{-1}. To produce [Fe II] 25.99 μm blueshifts of 20% wind speed requires that the emission arises closer to the star than existing thermal models for Oris circumstellar envelope predict. This implies a more rapid wind cooling to below 500 K within $10R_*$ ($\phi = 44\,$mas, $dist = 200\,$pc) of the star, where the wind has also reached a significant fraction of the maximum wind speed. The line width is consistent with the turbulence in the outflow being close to the hydrogen sound speed. EXES observations of [Fe II] 22.90 μm ($a^4D_{J=5/2-7/2}$: $E_{up} = 12,073\,$K) reveal no emission from either star. These findings confirm the dominance of cool plasma in the mixed region where hot chromospheric plasma emits copiously in the UV, and they also constrain the wind heating produced by the poorly understood mechanisms that drive stellar outflows from these low variability and weak-dust signature stars.

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A Search for L/T Transition Dwarfs With Pan-STARRS1 and *WISE*. III. Young L Dwarf Discoveries and Proper Motion Catalogs in Taurus and Scorpius-Centaurus

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We present the discovery of eight young M7-L2 dwarfs in the Taurus star-forming region and the Scorpius-Centaurus OB Association, serendipitously found during a wide-field search for L/T transition dwarfs using Pan-STARRS1 (optical) and WISE (mid-infrared) photometry. We identify PSO J060.3200+25.9644 (near-infrared spectral type L1) and PSO J077.1033+24.3809 (L2) as new members of Taurus based on their VL-G gravity classifications, the consistency of their photometry and proper motions with previously known Taurus objects, and the low probability of contamination by field objects. PSO J077.1033+24.3809 is the coolest substellar member of Taurus found to date. Both Taurus objects are among the lowest mass free-floating objects ever discovered, with estimated masses ≈6 M_{Jup}, and provide further evidence that isolated planetary-mass objects can form as part of normal star-formation processes. PSO J060.3200+25.9644 (a.k.a. DANCe J040116.80+255752.2) was previously identified as a likely member of the Pleiades (age ≈ 125 Myr) based on photometry and astrometry, but its VL-G gravity classification and near-infrared photometry imply a much younger age and thus point to Taurus membership. We have also discovered six M7-L1 dwarfs in outlying regions of Scorpius-Centaurus with photometry, proper motions, and low-gravity spectral signatures consistent with membership. These objects have estimated masses ≈15-36 M_{Jup}. The M7 dwarf, PSO J237.1470-23.1489, shows excess mid-infrared flux implying the presence of a circumstellar disk. Finally, we present catalogs of Pan-STARRS1 proper motions for low-mass members of Taurus and Upper Scorpius with median precisions of ≈3 mas $yr^{-}1$, including 67 objects with no previous proper motion and 359 measurements that improve on literature values.

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For preprints via WWW: https://arxiv.org/abs/1702.00789

Cross-Listed Abstracts (Pre-Main Sequence Stars)

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

CSI 2264: Simultaneous Optical and X-ray Variability in Pre-main Sequence Stars I: Time Resolved X-ray Spectral Analysis During Optical Dips and Accretion Bursts in Stars with Disks

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Pre-main sequence stars are variable sources. The main mechanisms responsible for their variability are variable extinction, unsteady accretion, and rotational modulation of both hot and dark photospheric spots and X-ray-active regions. In stars with disks, this variability is related to the morphology of the inner circumstellar region (≤ 0.1 AU) and that of the photosphere and corona, all impossible to be spatially resolved with present-day techniques. This has been the main motivation for the Coordinated Synoptic Investigation of NGC 2264, a set of simultaneous observations of NGC 2264 with 15 different telescopes.
In this paper, we focus on the stars with disks. We analyze the X-ray spectral properties extracted during optical bursts and dips in order to unveil the nature of these phenomena. Stars without disks are studied in a companion paper.
We analyze simultaneous CoRoT and *Chandra*/ACIS-I observations to search for coherent optical and X-ray flux variability in stars with disks. Then, stars are analyzed in two different samples. In stars with variable extinction, we look for a simultaneous increase of optical extinction and X-ray absorption during the optical dips; in stars with accretion bursts, we search for soft X-ray emission and increasing X-ray absorption during the bursts.
We find evidence for coherent optical and X-ray flux variability among the stars with variable extinction. In 9 of the 24 stars with optical dips, we observe a simultaneous increase of X-ray absorption and optical extinction. In seven dips, it is possible to calculate the N_H/A_V ratio in order to infer the composition of the obscuring material. In 5 of the 20 stars with optical accretion bursts, we observe increasing soft X-ray emission during the bursts that we associate to the emission of accreting gas. It is not surprising that these properties are not observed in all the stars with dips and bursts, since favorable geometric configurations are required.
The observed variable absorption during the dips is mainly due to dust-free material in accretion streams. In stars with accretion bursts, we observe, on average, a larger soft X-ray spectral component not observed in non-accreting stars.

Accepted by A&A

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For preprints via WWW: https://arxiv.org/abs/1701.04842

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.***