COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 217 — Oct.-Nov. 2018 Editor: Steve Skinner (coolnews@jila.colorado.edu)

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Coolnews on the Web

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Stellar Abstracts

The Rotational Evolution of Young, Binary M Dwarfs

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We have analysed K2 light curves for more than 3,000 low mass stars in the ∼8 Myr old Upper Sco association, the ∼125 Myr age Pleiades open cluster and the ∼700 Myr old Hyades and Praesepe open clusters to determine stellar rotation rates. Many of these K2 targets show two distinct periods, and for the lowest mass stars in these clusters virtually all of these systems with two periods are photometric binaries. The most likely explanation is that we are detecting the rotation periods for both components of these binaries. We explore the evolution of the rotation rate in both components of photometric binaries relative to one another and to non-photometric binary stars. In Upper

Sco and the Pleiades, these low mass binary stars have periods that are much shorter on average and much closer to each other than would be true if drawn at random from the M dwarf single stars. In Upper Sco, this difference correlates strongly with the presence or absence of infrared excesses due to primordial circumstellar disks – the single star population includes many stars with disks, and their rotation periods are distinctively longer on average than their binary star cousins of the same mass. By Praesepe age, the significance of the difference in rotation rate between the single and binary low mass dMs is much less, suggesting that angular momentum loss from winds for fully-convective zero-age main sequence stars erases memory of the rotation rate dichotomy for binary and single very low mass stars at later ages.

Accepted by AJ

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For preprints via WWW: https://arxiv.org/abs/1810.08548

Serendipitous X-ray Sources in the Chandra HRC Field around Alpha Centauri

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For more than a decade, Alpha Centauri AB (G2 V + K1 V) has been observed by *Chandra,* in a long-term program to follow coronal ($T \sim 10^6$ K) activity cycles of the two sunlike stars. Over 2008.4–2017.8, nineteen HRC-I exposures were taken, each about 10 ks in duration, and spaced about six months apart. Beyond monitoring the AB X-ray luminosities, the HRC-I sequence represents a unique decadal record of the dozen, or so, serendipitous X-ray sources in the α Cen field, which is at low Galactic latitude and thus dominated by nearby stars. For the present study, the ten brightest candidates were considered. Only a handful of these were persistent; most were variable, some highly so, flaring in a few epochs, weak or absent in the others. All ten X-ray sources have *Gaia* objects within about $2''$; mostly late-type dwarfs, but a few giants. However, two of the proposed optical counterparts have statistically significant offsets, and possible conflicts between the X-ray and optical properties. Another of the candidates brightened a factor of 100 in X-rays during a single exposure, briefly attaining super-flare status. The *Gaia* counterpart is anomalously blue for its absolute G-magnitude, and likely is a WD + dM pair. To the extent that the low Galactic latitude field is representative, the *Chandra* time-domain view emphasizes that the high-energy stellar sky is biased toward transient sources, so any snapshot survey surely will miss many of the most interesting objects.

Published in Astronomical Journal

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For preprints via WWW: http://adsabs.harvard.edu/abs/2018AJ....156..274A

The Advanced Spectral Library (ASTRAL): Reference Spectra for Evolved M-Stars

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The HST Treasury Program "Advanced Spectral Library Project: Cool Stars" was designed to collect representative, high quality ultraviolet spectra of eight evolved F−M type cool stars. The Space Telescope Imaging Spectrograph (STIS) echelle spectra of these objects enable investigations of a broad range of topics including stellar and interstellar astrophysics. This paper provides a guide to the spectra of the two evolved M-stars, the M2Iab supergiant α Ori and the M3.4 giant γ Cru, with comparisons to the prototypical K1.5 giant α Boo. It includes identifications of the significant atomic and molecular emission and absorption features and discusses the character of the photospheric and chromospheric continua and line spectra. The fluorescent processes responsible for a large portion of the emission line spectrum, the characteristics of the stellar winds, and the available diagnostics for hot and cool plasmas are also summarized. This analysis will facilitate the future study of the spectra, outer atmospheres, and winds, not only of these objects, but for numerous other cool, low-gravity stars for years to come.

Accepted by ApJ

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For preprints via ftp or WWW: http://arxiv.org/abs/1811.11865

HST/GHRS Observations of Cool, Low-Gravity Stars VI. Mass-Loss Rates and Wind Parameters for M Giants

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The photon-scattering winds of M-giants absorb parts of the chromospheric emission lines and produce self-reversed spectral features in high resolution *HST*/GHRS spectra. These spectra provide an opportunity to assess fundamental parameters of the wind, including flow and turbulent velocities, the optical depth of the wind above the region of photon creation, and the star's mass-loss rate. This paper is the last paper in the series "GHRS Observations of Cool, Low-Gravity Stars"; the last several have compared empirical measurements of spectral emission lines with models of the winds and mass-loss of K-giant and supergiants. We have used the Sobolev with Exact Integration (SEI) radiative transfer code, along with simple models of the outer atmosphere and wind, to determine and compare the wind characteristics of the two M-giant stars, γ Cru (M3.5III) and μ Gem (M3IIIab), with previously derived values for low-gravity K-stars. The analysis specifies the wind parameters and calculates line profiles for the Mg II resonance lines, in addition to a range of unblended Fe II lines. Our line sample covers a large range of wind opacities and, therefore, probes a range of heights in the atmosphere.

Our results show that μ Gem has a slower and more turbulent wind then γ Cru. Also, μ Gem has weaker chromosphere, in terms of surface flux, with respect to γ Cru. This suggests that μ Gem is more evolved than γ Cru. Comparing the two M-giants in this work with previously studied K-giant and supergiant stars (α Tau, γ Dra, λ Vel) reveals that the M-giants have slower winds than the earlier giants, but exhibit higher mass-loss rates. Our results are interpreted in the context of the winds being driven by Alfvén waves.

Accepted by ApJ, Vol. 869, Pag. 1

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For preprints via ftp or WWW: https://doi.org/10.3847/1538-4357/aaf0a0

First Long-term Activity Study of AU Microscopii: A Possible Chromospheric Cycle

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M stars are ideal targets to search for Earth-like planets. However, they usually have high levels of magnetic activity, which could affect their habitability and make difficult the detection of exoplanets orbiting around them. Unfortunately, long-term variability of dM stars has not been extensively studied, due to their low intrinsic brightness. For this reason, in 1999 we started the HKα project, which systematically observes the spectra of a large number of stars, in particular dM stars, at the Complejo Astronómico El Leoncito (CASLEO). In this work, we study the long-term activity of the young active dM1 star AU Microscopii. We analyze the Mount Wilson index S derived from CASLEO spectra obtained between 2004 and 2016, which we complement with the S-index derived from HARPS, FEROS and UVES public spectra. We also analyze the simultaneous photometric counterpart provided by the ASAS public database for this star between 2000 and 2009, and our own photometry. In both totally independent time series, we detect a possible activity cycle of period $\sim$ 5 years. We also derived a precise rotation period for this star $P_{rot} = 4.85$ days, consistent with the literature. This activity cycle reflects that an $\alpha\Omega$ dynamo could be operating in this star.

Accepted by MNRAS

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Solar Abstracts

Principal Component Analysis of Sunspot Cycle Shape

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Aims. We study the shape of sunspot cycles using the Wolf sunspot numbers and group sunspot numbers of solar cycles 1-23. We determine the most typical "model" cycles and the most asymmetric cycles, and test the validity of the two Waldmeier rules: the anti-correlation between cycle height and the length of its ascending phase (rule 1), and between cycle height and the length of the preceding cycle (rule 2).

Methods. We applied the principal component analysis to sunspot cycles and studied the first two components, which describe the average cycle shape and cycle asymmetry, respectively. We also calculated their autocorrelation in order to study their recurrence properties.

Results. The best model cycles for Wolf numbers are SC12, SC14, and SC16, the successive even cycles from a long period of rather low overall solar activity. We find that the model cycles in eight different analyses using both sunspot series are almost exclusively even cycles. Correspondingly, the most asymmetric cycles are odd cycles.

We find that both Waldmeier rules are valid for the whole Wolf number series of 23 cycles. Waldmeier rule 2 is also valid for group number series although its significance is weaker. Waldmeier rule 1 is not significant for the original group number series, but becomes significant for the proxy series.

For separate centuries, Waldmeier rules are not always valid for Wolf numbers and very rarely for group numbers.

Conclusions. The preference of even cycles as model cycles supports the Gnevyshev-Ohl rule and the related 22-year alternation of cycle amplitudes and intensities, with even cycles on average being 10-15% lower than odd cycles. Our results also offer a new interpretation for the Gnevyshev gap. In addition to being a local depression of solar activity, the Gnevyshev gap is a separatrix that divides cycles into two parts whose relative intensities determine the cycle asymmetry. The Gnevyshev gap is the zero value time of PC2, located approximately 33-42% into the cycle after its start.

Accepted by A&A

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Solar Polar Brightening and Radius at 100 and 230 GHZ Observed by ALMA

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Polar brightening of the Sun at radio frequencies has been studied for almost fty years and yet a disagreement persists between solar atmospheric models and observations. Some observations reported brightening values much smaller than the expected values obtained from the models, with discrepancies being particularly large at millimeter wavelengths. New clues to calibrate the atmospheric models can be obtained with the advent of the Atacama Large Millimeter/submillimeter Array (ALMA) radio interferometer. In this work, we analyzed the lower limit of the polar brightening observed at 100 and 230 GHz by ALMA, during its Science Verication period, 2015 December 16-20. We nd that the average polar intensity is higher than the disk intensity at 100 and 230 GHz, with larger brightness intensities at the South pole in eight of the nine maps analyzed. The observational results were compared with calculations of the millimetric limb brightnening emission for two semi-empirical atmospheric models, FAL-C (Fontenla et al. 1993) and SSC (Selhorst et al. 2005a). Both models presented larger limb intensities than the averaged observed values. The intensities obtained with the SSC model were closer to the observations, with polar brightenings of 10.5% and 17.8% at 100 and 230 GHz, respectively. This discrepancy may be due to the presence of chromospheric features (like spicules) at regions close to the limb.

Accepted by ApJ

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For preprints via WWW: https://arxiv.org/abs/1811.12158v1

Chemical Tracers in Proto-brown Dwarfs: CO, ortho-H_2CO, para-H_2CO, HCO^+, CS Observations

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We present a study of the CO isotopologues and the high-density tracers H_2CO, HCO^+, and CS in Class 0/I proto-brown dwarfs (proto-BDs). We have used the IRAM 30m telescope to observe the ^{12}CO (2-1), ^{13}CO (2-1), $C^{18}O$ (2-1), $C^{17}O$ (2-1), H_2CO (3-2), HCO^+ (3-2), and CS (5-4) lines in 7 proto-BDs. The hydrogen column density for the proto-BDs derived from the CO gas emission is ∼2-15 times lower than that derived from the dust continuum emission, indicating CO depletion from the gas-phase. The mean H_2CO ortho-to-para ratio is ∼3 for the proto-BDs and indicates gas-phase formation for H_2CO. We have investigated the correlations in the molecular abundances between the proto-BDs and protostars. Proto-BDs on average show a factor of ∼2 higher ortho-to-para H_2CO ratio than the protostars. Possible explanations include a difference in the H_2CO formation mechanism, spin-selective photo-dissociation self-shielding effects, or different emitting regions for the ortho and para species. There is a tentative trend of a decline in the HCO^+ and H_2CO abundances with decreasing bolometric luminosity, while the CS and CO abundances show no particular difference between the proto-BDs and protostars. These trends reflect the scaled-down physical structures for the proto-BDs compared to protostars and differences in the peak emitting regions for these species. The $C^{17}O$ isotopologue is detected in all of the proto-BDs as well as the more evolved Class Flat/Class II BDs in our sample, and can probe the quiescent gas at both early and late evolutionary stages.

Accepted by MNRAS

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For preprints via WWW: https://arxiv.org/abs/1811.01722

Book Chapter Abstract

Science with an ngVLA – Stellar Activity on Red Giant and Supergiant Stars: Mass Loss and the Evolution of the Stellar Dynamo.

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In this Chapter we examine the role of the ngVLA to further our understanding of the different manifestations of convective or turbulence-driven stellar activity on red giant and supergiant stars. The combination of high spatial resolution and high sensitivity will enable the ngVLA to significantly improve our understanding of the processes that dissipate energy in the extended atmospheres of cool evolved stars, and drive ubiquitous stellar outflows. The high spatial resolution will enable us to image the surfaces of nearby red supergiants, and to measure the atmospheric extent of red giants. Multi-frequency observations will permit thermal continuum tomography on the largest angular diameter stars, providing key empirical data to test theoretical models. The complementary frequencies and similar spatial resolutions of the ngVLA and ALMA will be a powerful synergy.

To be published in the ASP Monograph Series, Science with a Next-Generation VLA, ed. E. J. Murphy (ASP, San Francisco, CA)

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For preprints via WWW: https://arxiv.org/abs/1810.09353

Upcoming Meeting

Space Climate 7

8 - 11 July 2019

Quebec, Candada

FIRST ANNOUNCEMENT

Dear Colleagues and Friends!

We have the great pleasure to invite you to *Space Climate 7* to be held at Auberge Estrimont, Canton Orford, in the mountains east of Montreal, in Quebec, Canada, on 8-11 July 2019, just before the IAGA meeting (during early IUGG) in Montreal.

Details on venue, registration, scientific program and accommodation is available at the meeting website:

http://craq-astro.ca/spaceclimate7/

For questions related to the meeting, send an email to:

spaceclimate7@astro.umontreal.ca

Please note that the number of attendees will be limited to 120 because of the meeting venue.

Welcome to Space Climate 7 in Orford!

Sincerely Yours,

Paul Charbonneau (LOC chair)
Cassandra Bolduc (LOC vice-chair)
Kalevi Mursula (SOC chair)
Ilya Usoskin (SOC 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.***