COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Fluorine in a Carbon-Enhanced Metal-Poor Star

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The fluorine abundance of the Carbon-Enhanced Metal-Poor (CEMP) star HE 1305+0132 has been derived by analysis of the molecular HF (1-0) R9 line at 2.3357 μm in a high-resolution ($R = 50,000$) spectrum obtained with the Phoenix spectrometer and Gemini-South telescope. Our abundance analysis makes use of a CNO-enhanced ATLAS12 model atmosphere characterized by a metallicity and CNO enhancements determined utilizing medium-resolution ($R = 3,000$) optical and near-IR spectra. The effective iron abundance is found to be [Fe/H] = -2.5, making HE 1305+0132 the most Fe-deficient star, by more than an order of magnitude, for which the abundance of fluorine has been measured. Using spectral synthesis, we derive a super-solar fluorine abundance of A(^{19}F) = 4.96 $\pm$0.21, corresponding to a relative abundance of [F/Fe] = 2.90. A single line of the Phillips C_2 system is identified in our Phoenix spectrum, and along with multiple lines of the first-overtone vibration-rotation CO (3-1) band head, C and O abundances of A(^{12}C) = 8.57 $\pm$0.11 and A(^{16}O) = 7.04 $\pm$0.14 are derived. We consider the striking fluorine overabundance in the framework of the nucleosynthetic processes thought to be responsible for the C-enhancement of CEMP stars and conclude that the atmosphere of HE 1305+0132 was polluted via mass transfer by a primary companion during its asymptotic giant branch phase. This is the first study of fluorine in a CEMP star, and it demonstrates that this rare nuclide can be a key diagnostic of nucleosynthetic processes in the early Galaxy.

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Theoretical Model Atmosphere Spectra Used for the Calibration of Infrared Instruments

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One of the key ingredients in establishing the relation between input signal and output flux from a spectrometer is accurate determination of the *spectrophotometric calibration.* In the case of spectrometers onboard satellites, the accuracy of this part of the calibration pedigree is ultimately linked to the accuracy of the set of reference spectral energy distributions (SEDs) that the spectrophotometric calibration is built on. In this paper, we deal with the spectrophotometric calibration of *infrared* (IR) spectrometers onboard satellites in the 2 to 200 μm wavelength range. We aim at comparing the different reference SEDs used for the IR spectrophotometric calibration. The emphasis is on the reference SEDs of *stellar standards* with spectral type later than A0, with special focus on the theoretical model atmosphere spectra. Using the MARCS model atmosphere code, spectral reference SEDs were constructed for a set of IR stellar standards (A dwarfs, solar analogs, G9-M0 giants). A detailed error analysis was performed to estimate proper uncertainties on the predicted flux values. It is shown that the uncertainty on the predicted fluxes can be as high as 10 %, but in case high-resolution observational optical or near-IR data are available, and IR excess can be excluded, the uncertainty on medium-resolution SEDs can be reduced to 1–2 % in the near-IR, to ∼3 % in the mid-IR, and to ∼5 % in the far-IR. Moreover, it is argued that theoretical stellar atmosphere spectra are at the moment the best representations for the IR fluxes of cool stellar standards. When aiming at a determination of the spectrophotometric calibration of IR spectrometers better than 3 %, effort should be put into constructing an appropriate set of stellar reference SEDs based on theoretical atmosphere spectra for some 15 standard stars with spectral types between A0 V and M0 III.

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The Variable Mass Loss of the AGB Star WX Psc as Traced by the CO $J = 1-0$ Through $7-6$ Lines and the Dust Emission.

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Low and intermediate mass stars lose a significant fraction of their mass through a dust-driven wind during the Asymptotic Giant Branch (AGB) phase. Recent studies show that winds from late-type stars are far from being smooth. Mass-loss variations occur on different time scales, from years to tens of thousands of years. The variations appear to be particularly prominent towards the end of the AGB evolution. The occurrence, amplitude and time scale of these variations are still not well understood.

The goal of our study is to gain insight into the structure of the circumstellar envelope (CSE) of WX Psc and map the possible variability of the late-AGB mass-loss phenomenon.

We have performed an in-depth analysis of the extreme infrared AGB star WX Psc by modeling *(1)* the CO $J = 1-0$ through $7-6$ rotational line profiles *and* the full spectral energy distribution (SED) ranging from 0.7 to 1300 μm. We hence are able to trace a geometrically extended region of the CSE.

Both mass-loss diagnostics bear evidence of the occurrence of *mass-loss modulations* during the last ∼2000 yr. In

particular, WX Psc went through a high mass-loss phase ($\dot{M} \sim 5\,10^{-5}\,M_{\odot}$/yr) some 800 yr ago. This phase lasted about 600 yr and was followed by a long period of low mass loss ($\dot{M} \sim 5\,10^{-8}\,M_{\odot}$/yr). The present day mass-loss rate is estimated to be $\sim 6\,10^{-6}\,M_{\odot}$/yr.

The AGB star WX Psc has undergone strong mass-loss rate variability on a time scale of several hundred years during the last few thousand years. These variations are traced in the strength and profile of the CO rotational lines and in the SED. We have consistently simulated the behaviour of both tracers using radiative transfer codes that allow for non-constant mass-loss rates.

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Line Shift, Line Asymmetry, and the ^{6}Li/^{7}Li Isotopic Ratio Determination

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Context: Line asymmetries are generated by convective Doppler shifts in stellar atmospheres, especially in metal-poor stars, where convective motions penetrate to higher atmospheric levels. Such asymmetries are usually neglected in abundance analyses. The determination of the ^{6}Li/^{7}Li isotopic ratio is prone to suffering from such asymmetries, as the contribution of ^{6}Li is a slight blending reinforcement of the red wing of each component of the corresponding ^{7}Li line, with respect to its blue wing.
Aims: The present paper studies the halo star HD 74000 and estimates the impact of convection-related asymmetries on the Li isotopic ratio determination.
Method: Two methods are used to meet this aim. The first, which is purely empirical, consists in deriving a template profile from another element that can be assumed to originate in the same stellar atmospheric layers as Li I, producing absorption lines of approximately the same equivalent width as individual components of the ^{7}Li I resonance line. The second method consists in conducting the abundance analysis based on NLTE line formation in a 3D hydrodynamical model atmosphere, taking into account the effects of photospheric convection.
Results: The results of the first method show that the convective asymmetry generates an excess absorption in the red wing of the ^{7}Li absorption feature that mimics the presence of ^{6}Li at a level comparable to the hitherto published values. This opens the possibility that only an upper limit on ^{6}Li/^{7}Li has thus far been derived. The second method confirms these findings.
Conclusions: From this work, it appears that a systematic reappraisal of former determinations of ^{6}Li abundances in halo stars is warranted.

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Improved Photometric Calibrations for Red Stars Observed with the SDSS Photometric Telescope

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We present a new set of photometric transformations for red stars observed with the Sloan Digital Sky Survey (SDSS) 0.5-m Photometric Telescope (PT) and the SDSS 2.5-m telescope at the Apache Point Observatory in New Mexico. Nightly PT observations of US Naval Observatory standards are used to determine extinction corrections and calibration terms for SDSS 2.5-m photometry. Systematic differences between the PT and native SDSS 2.5-m *ugriz* photometry require conversions between the two systems which have previously been undefined for the reddest stars. By matching $\sim 43,000$ stars observed with both the PT and SDSS 2.5-m, we extend the present relations to include low-mass stars with colors $0.6 \leq r - i \leq 1.7$. These corrections will allow us to place photometry of bright, low-mass trigonometric parallax stars previously observed with the PT on the 2.5-m system. We present new transformation equations and discuss applications of these data to future low-mass star studies using the SDSS.

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Atomic Diffusion and Mixing in Old Stars I. VLT/FLAMES-UVES Observations of Stars in NGC 6397

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We present a homogeneous photometric and spectroscopic analysis of 18 stars along the evolutionary sequence of the metal-poor globular cluster NGC 6397 ([Fe/H] ≈ -2), from the main-sequence turnoff point to red giants below the bump. The spectroscopic stellar parameters, in particular stellar-parameter differences between groups of stars, are in good agreement with broad-band and Stromgren photometry calibrated on the infrared-flux method. The spectroscopic abundance analysis reveals, for the first time, systematic trends of iron abundance with evolutionary stage. Iron is found to be 31% less abundant in the turnoff-point stars than in the red giants. An abundance difference in lithium is seen between the turnoff-point and warm subgiant stars. The impact of potential systematic errors on these abundance trends (stellar parameters, the hydrostatic and LTE approximations) is quantitatively evaluated and found not to alter our conclusions significantly. Trends for various elements (Li, Mg, Ca, Ti and Fe) are compared with stellar-structure models including the effects of atomic diffusion and radiative acceleration. Such models are found to describe the observed element-specific trends well, if extra (turbulent) mixing just below the convection zone is introduced. It is concluded that atomic diffusion and turbulent mixing are largely responsible for the sub-primordial stellar lithium abundances of warm halo stars. Other consequences of atomic diffusion in old metal-poor stars are also discussed.

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Photospheric Magnetic Evolution of Super Active Regions

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Context Solar flares are one of the most interesting phenomena of solar activity. Although many authors agree that their energy release is related to magnetic reconnection, the phases preceding the magnetic reconnection process are still unclear in several respects.
Aims We studied the magnetic flux evolution in 26 super active regions observed on the solar disc from Jan 1, 2000 to Dec 31, 2006, in order to determine a physical relationship between flares and some properties of the photospheric magnetic fields.
em Methods This analysis is based on full disc line of sight MDI magnetograms. We measured the total magnetic flux, the magnetic flux imbalance, the horizontal magnetic gradient and the number of magnetic features characterized by a collection of pixels lying in the same bins of absolute strength. We also elaborated an algorithm for the identification and the length measurement of the magnetic inversion lines.
Results We found a correlation between the evolution of the analyzed parameters and the flare occurrence. The most intense phases of activity are associated with phases of emergence of a magnetic field in 15 super active regions and with phases of flux cancellation in 5 super active regions.
Conclusions Super active regions may be characterized by a different behavior depending on their morphology. Some of them show a continuous flare activity, while others present an alternation of active and quiet phases. The deviations from magnetic polarity balance and the length of the inversion lines characterized by a horizontal magnetic gradient greater than 0.3 G km^{-1} seem to have a major role in producing a magnetic field topology able to trigger flares.

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Magnetic Flux in the Solar Convective Envelope Inferred from the Initial Observations of the Sunspots

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Different life spans of the sunspots suggest their origin at different depths and by measuring magnetic fluxes from their first observation on the surface, one can estimate the strength of magnetic flux at different anchoring depths. From the SOHO/MDI magnetograms, we infer the strength of magnetic flux and rate of emergence of magnetic flux at different anchoring depths in the solar convective envelope by measuring *initial* magnetic fluxes of the well developed sunspots on the surface. Important findings are : (i) majority of the spot groups that have *first* observation on the surface are bipolar, (ii) irrespective of their sizes, the bipolar spots with different life spans have average magnetic field strengths of $\sim$ 500 G during their first observation, (iii) the average field strength at the site of anchoring depths of the sunspots is estimated to be $\sim 10^6$ G near base of the convective envelope and $\sim 10^4$ G near the surface, (iv) the dynamo-a source of sunspot activity- is distributed through out the convective envelope and, (v) the rate of emergence of *initial* magnetic flux of such a distributed dynamo near base of the convection zone is $\sim$ 6 X 10^{19} Mx/day and is 40% higher than the the rate of emergence of *initial* magnetic flux near the surface.
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Low-Mass and Substellar Abstracts

A High Resolution Spectral Atlas of Brown Dwarfs

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We present a UVES/VLT high resolution atlas of three L dwarfs and one T dwarf system, spectral classes at which most of the objects are brown dwarfs. Our atlas covers the optical region from Hα up to the near infrared at $1\,\mu$m. We present spectral details of ultra-cool atmospheres at very high resolution ($R \sim 33\,000$) and compare the spectra to model calculations. Our comparison shows that molecular features from VO and CaH, and atomic features from Cs and Rb are reasonably well fit by current models. On the other hand, features due to TiO, CrH, and water, and atomic Na and K reveal large discrepancies between model calculations and our observations.

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Cross-listed Abstracts (PMS Stars)

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

Evidence for Accretion in the High-resolution X-ray Spectrum of the T Tauri Star System Hen 3-600

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We present high-resolution X-ray spectra of the multiple T Tauri star system Hen 3-600, obtained with the High Energy Transmission Grating Spectrograph on the Chandra X-ray Observatory. Two binary components were detected in the zeroth-order image. Hen 3-600-A, which has a large mid-infrared excess, is a 2-3 times fainter in X-rays than Hen 3-600-B, due to a large flare on B. The dispersed X-ray spectra of the two primary components overlap spatially; spectral analysis was performed on the combined system. Analysis of the individual spectra was limited to regions where the contributions of A and B can be disentangled. This analysis results in two lines of evidence indicating that the X-ray emission from Hen 3-600 is derived from accretion processes: line ratios of O VII indicate that the characteristic density of its X-ray-emitting plasma is large; a significant component of low-temperature plasma is present and is stronger in component A. These results are consistent with results obtained from X-ray gratings spectroscopy of more rapidly accreting systems. All of the signatures of Hen 3-600 that are potential diagnostics of accretion activity — X-ray emission, UV excess, H-alpha emission, and weak infrared excess — suggest that its components represent a transition phase between rapidly accreting, classical T Tauri stars and non-accreting, weak-lined T Tauri stars.

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The X-ray Soft Excess in Classical T Tauri Stars

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Aims: We study an anomaly in the X-ray flux (or luminosity) ratio between the O VII $\lambda\lambda$21.6-22.1 triplet and the O VIII Lyα line seen in classical T Tauri stars (CTTS). This ratio is unusually high when compared with ratios for main-sequence and non-accreting T Tauri stars (Telleschi et al. 2007). We compare these samples to identify the source of the excess. A sample of recently discovered X-ray stars with a soft component attributed to jet emission is also considered.
Methods: We discuss data obtained from the *XMM-Newton Extended Survey of the Taurus Molecular Cloud* (XEST) project, complemented by data from the published literature. We also present data from the CTTS RU Lup.
Results: All CTTS in the sample show an anomalous O VII/O VIII flux ratio when compared with WTTS or MS stars. The anomaly is due to an *excess* of cool, O VII emitting material rather than a deficiency of hotter plasma. The excess plasma must therefore have temperatures of les than approximately 2 MK. This *soft excess* does not correlate with UV excesses of CTTS, but seems to be related with the stellar X-ray luminosity. The spectra of the jet-driving TTS do not fit into this picture.
Conclusions: The soft excess depends both on the presence of accretion streams in CTTS and on magnetic activity. The gas may be shock-heated near the surface, although it may also be heated in the magnetospheric accretion funnels. The soft component of the jet-driving sources is unlikely to be due to the same process.

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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 monthly call for abstracts will be issued and abstracts received by the last day of the month will usually appear in the following month's newsletter. 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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