COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Hyades Oxygen Abundances from the [O I] λ6300 Line: The Giant-Dwarf Oxygen Discrepancy Revisited

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We present the results of our abundance analysis of Fe, Ni, and O in high S/N, high-resolution VLT/UVES and McDonald/2dcoudé spectra of nine dwarfs and three giants in the Hyades open cluster. The difference in Fe abundances derived from Fe II and Fe I lines ([Fe II/H] – [Fe I/H]) and Ni I abundances derived from moderately high-excitation lines are found to increase with decreasing $T_{\rm eff}$ for the dwarfs. Both of these findings are in concordance with previous results of over-excitation/ionization in cool young dwarfs. Oxygen abundances are derived from the λ6300 [O I] line, with careful attention given to the Ni I blend. The dwarf O abundances are in star-to-star agreement within uncertainties, but the abundances of the three coolest dwarfs evince an increase with decreasing $T_{\rm eff}$. Possible causes for the apparent trend are considered, including the effects of over-dissociation of O-containing molecules. O abundances are derived from the near-UV λ3167 OH line in high-quality Keck/HIRES spectra, and no such effects are found–indeed, the OH-based abundances show an increase with decreasing $T_{\rm eff}$, leaving the nature and reality of the cool dwarf [O I]-based O trend uncertain. The mean relative O abundance of the six warmest dwarfs is $[{\rm O/H}] = +0.14 \pm 0.02$, and we find a mean abundance of $[{\rm O/H}] = +0.08 \pm 0.02$ for the giants. Thus, our updated analysis of the λ6300 [O I] line does not confirm the Hyades giant-dwarf oxygen discrepancy initially reported by King & Hiltgen. LTE Oxygen abundances from the near-IR, high-excitation O I triplet are also derived for the giants, and the resulting abundances are approximately 0.28 dex higher than those derived from the [O I] line, in agreement with NLTE predictions. Finally, Hyades giant and dwarf O abundances as derived from the λ6300 [O I] line and high-excitation triplet, as well as dwarf O abundances derived from the near-UV λ3167 OH line, are compared, and a mean cluster O abundance of $[{\rm O/H}] = +0.12 \pm 0.02$ is achieved and represents the best estimate of the Hyades O abundance.

Accepted by AJ

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Infrared Spectroscopy of Symbiotic Stars. IV. V2116 Ophiuchi/GX 1+4, The Neutron Star Symbiotic

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We have computed, based on 17 infrared radial velocities, the first set of orbital elements for the M giant in the symbiotic binary V2116 Ophiuchi. The giant's companion is a neutron star, the bright X-ray source GX 1+4. We rule out the previously proposed period of 304 days, and instead, find an orbital period of 1161 days, by far the longest of any known X-ray binary. The orbit has a modest eccentricity of 0.10 with an orbital circularization time of about 5 x 10^6 years or less. The large mass function of the orbit significantly restricts the mass of the M giant. Adopting a neutron-star mass of 1.35 solar masses, the *maximum* mass of the M giant is 1.22 solar masses, making it the less massive star. Spectrum synthesis analysis of several infrared spectral regions results in slightly subsolar abundances for most metals. Carbon and nitrogen are in the expected ratio resulting from the red-giant first dredge-up phase. The lack of ^{17}O suggests that the M-giant has a mass less than 1.3 solar masses, consistent with our maximum mass. The surface gravity and maximum mass of the M giant result in a radius of 103 solar radii, much smaller than its estimated Roche lobe radius. Thus, the mass loss of the red giant is via a stellar wind. These properties argue that the M giant is near the tip of the first-ascent giant-branch. Although the M giant companion to the neutron star has a mass similar to the late-type star in low-mass X-ray binaries, its near-solar abundances and apparent runaway velocity are not fully consistent with the properties of this class of stars. Thus, in many ways this symbiotic and X-ray binary system is unique, and various scenarios for its possible evolution are discussed.

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Influence of Gravity Waves on the Internal Rotation and Li Abundance of Solar-type Stars

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The Sun's rotation profile and lithium content has been difficult to understand in the context of conventional models of stellar evolution. Classical hydrodynamical models predict that the solar interior must rotate highly differentially in disagreement with observations. It was recently shown that internal waves produced by convection in solar-type stars produce an asymmetric shear layer oscillation, similar to the Earth's quasi-biennal oscillation, that leads to efficient angular momentum redistribution from the core to the envelope. We present results of a model that successfully reproduces both the rotation profile and the surface abundance of lithium in solar-type stars of various ages. Science, Vol. 309, Issue 5744, 2189-2191

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Ca II Chromospheric Emission Lines in Late K and M Dwarfs

Emily Rauscher[1], Geoff Marcy[1]

[1] Department of Astronomy MS 3411, UC Berkeley, Berkeley, CA, 94720 We have measured the profiles of the Ca II chromospheric emission lines in 147 main sequence stars of spectral type M5-K7 (masses 0.30-0.55 Solar masses) using multiple high resolution spectra obtained during six years with HIRES spectrometer on the Keck 1 telescope. Remarkably, the average FWHM, equivalent widths, and line luminosities of Ca II H&K emission increase by a factor of 4 with increasing stellar mass over this small range of stellar masses. We fit the Ca II lines with a double Gaussian model to represent both the chromospheric emission and the non-LTE central absorption. Most of the sample stars display a central absorption reversal that is typically redshifted by $\sim$0.1 km s^{-1} relative to the emission. This implies that the lower density, high-level chromospheric material has a smaller outward velocity (or higher inward velocity) than the lower-level material in the chromosphere, but the nature of this velocity gradient in not known. The FWHM of the Ca II H &K lines increases with stellar luminosity, reminiscent of the Wilson-Bappu effect in FGK-type stars. Both the equivalent widths and FWHM exhibit modest temporal variability in individual stars. At a given value of M_V, stars exhibit a spread in both the equivalent width and FWHM of Ca II, due both to a spread in fundamental stellar parameters including rotation rate, age, and possibly metallicity, and to the spread in stellar mass at a given M_V. The K line is consistently wider than the H line, as expected, and its central absorption is more redshifted, indicating that the H and K lines form at slightly different heights in the chromosphere where the velocities are slightly different. The equivalent width of Hα correlates with Ca II H&K only for stars having Ca II equivalent widths above $\sim$2 Å, suggesting the existence of a magnetic threshold above which the lower and upper chromosphere become thermally coupled.

Submitted to PASP

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A Large Millimeter Flare on the RS CVn Binary σ Geminorum

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The flaring behavior of active RS CVn binaries has been studied extensively at cm wavelengths, but very little has been published concerning RS CVn flares in the millimeter region where the nonthermal gyrosynchrotron emission is much more likely to be optically thin. We present 3 mm (99 GHz) observations of a large flare on the active binary σ Gem using the Owens Valley Millimeter Array. Two 3 hour observations in 2004 February showed only 3σ upper limits of 3 mJy, while the third observation on 2004 April 22 showed a large flare outburst that filled the 6 hour observation and reached a peak flux density of 90 mJy. The strongest brightening was preceded by at least a four hour period of significantly elevated emission at 20-40 mJy. These observations demonstrate the feasibility of detailed multifrequency studies of nonthermal electron distributions in active star coronae with the next generation of mm and cm radio arrays.

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XMM-Newton X-ray Spectroscopy of Classical T Tauri Stars

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We present results from a comparative study of XMM-Newton observations of four classical T Tauri stars (CTTS), namely BP Tau, CR Cha, SU Aur and TW Hya. In these objects coronal, i.e. magnetic, activity and as recently shown, magnetically funneled accretion are the processes likely to be responsible for the generation of X-ray emission. Variable X-ray emission with luminosities in the order of 10^{30} erg/s is observed for all targets. We investigate light curves as well as medium and high-resolution X-ray spectra to determine the plasma properties of the sample CTTS and to study the origin of their X-ray emission and its variability. The emission measure distributions and observed

temperatures differ significantly and the targets are dominated either by plasma at high densities as produced by accretion shocks or by predominantly hotter plasma of coronal origin. Likewise the variability of the X-ray luminosity is found to be generated by both mechanisms. Cool plasma at high densities is found in all stars with detected O VII triplet emission, prevented only for SU Aur due to strong absorption. A general trend is present in the abundance pattern, with neon being at solar value or enhanced while oxygen, iron and most other metals are depleted, pointing to the presence of the inverse FIP effect in active coronae and possibly grain formation in evolved disks. We find that both accretion shocks and coronal activity contribute to the observed X-ray emission of the targets. While coronal activity is the dominant source of X-ray activity in the majority of the CTTS, the fraction for each process differs significantly between the individual objects.

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Editor's Note: The above abstract is being cross-listed in the Star Formation Newsletter.

Solar Abstracts

Analysis of a Multi-wavelength Time-resolved Observation of a Coronal Loop

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Several items on the diagnostics and interpretation of coronal loop observations are under debate. In this work, we analyze a well-defined loop system detected in a time-resolved observation in several spectral bands to study how far one can go in characterizing the loop structure and evolution. The dataset includes simultaneous sequences of images in the 171 Å, 195 Å and 284 Å filter bands of TRACE, and in one filter of Yohkoh/SXT, with a time coverage of about 2.5 hours, and two rasters taken with SoHO/CDS in twelve relevant lines, forming between $\log T \approx 5.4$ (O V 629 Å) and $\log T \approx 6.4$ (Fe XVI 360 Å). The loop is initially best visible in the TRACE 195 Å filter band, with some correspondence with the simultaneous SXT images, and later in the 171 Å filter band, with good correspondence with the CDS raster images in the lines with formation temperature around $\log T \approx 6.0 - 6.1$. We have taken as pixel-by-pixel background the latest TRACE, Yohkoh and CDS images where the loop has faded out. We examine the loop morphology evolution, the light curves, the TRACE filter ratio distribution and evolution, the images and emission measure from the CDS spectral lines. Our analysis detects that, after background subtraction, the emission along theloop and its evolution are non-uniform, especially in the 171 Å filter band, and that the TRACE 195/171 filter ratio has a moderately non-uniform distribution along the loop and evolves in time. Both the light curves and the filter ratio evolution indicate a globally cooling loop. Relatively hot plasma may be present at the beginning while, during the first CDS raster, the data indicate a rather moderate thermal structuring of the loop. Our data analysis supports a coherent scenario across the different bands and instruments, points out difficulties in diagnostic methods and puts quantitative basis for detailed forward modeling.

Accepted by A&A

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The Long Dance of the Bashful Ballerina

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In this letter we extend our earlier analysis of the north-south asymmetry of the heliospheric current sheet (HCS) using a recent data set of heliospheric magnetic field (HMF) sector polarities extracted from ground-based magnetic observations. We find that the HCS is similarly southward coned or shifted during the late declining to minimum phase of the solar cycle in the early part of the studied data interval (1926-1955), as earlier found for the more recent solar cycles. Accordingly, the HCS has been southward coned or shifted, i.e., the solar ballerina has been bashful at least during the last 80 years. We also discuss solar cycle 19 which presents a period of a very curious behaviour for the HCS with an exceptionally large HMF toward sector dominance in 1957, the year of cycle 19 maximum, and an equally strong HMF away sector dominance in 1960, the time of final solar polarity reversal.

Accepted by GRL

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Job Openings

PhD Student Fellowships

Armagh Observatory (N. Ireland)

Applications are invited for fixed-term postgraduate research studentships tenable at the Armagh Observatory from 1 October 2006. Facilities at the Observatory for modelling and data reduction are excellent. Staff at the Observatory regularly receive awards of telescope time (both ground and space-based) and research grants from PPARC, the EU and other organizations. The Observatory also has access to the Southern African Large Telescope (SALT), a 10-metre class telescope located at the Sutherland Observatory, South Africa.

Research interests of Observatory staff include (i) Stellar and Galactic Astrophysics (e.g. brown dwarfs, hot stars and helium stars); (ii) the Sun (the dynamic solar atmosphere, chromosphere and corona); and (iii) Solar System Astronomy (including celestial mechanics, planetary science, and the dynamical interrelationships between comets, asteroids and interplanetary dust, and NEOs). Further details concerning the research interests of all the Observatory staff may be obtained from the Observatory web-site at: http://star.arm.ac.uk/.

Candidates must have, or expect to obtain, at least an upper second class honours degree or the equivalent in an appropriate discipline (e.g. Physics, Mathematics, Astronomy or Astrophysics). The successful candidate will enroll at an appropriate university and carry out a research programme at the Armagh Observatory. Enrolment for a PhD will be in accordance with the regulations of the governing university.

For details on the list of possible projects and the application procedure, please visit
http://star.arm.ac.uk/phd/ or email to jgd@arm.ac.uk

First selection will take place as soon as possible after 28 February 2006 with subsequent selections in mid-May and periodically thereafter until all positions have been filled.

Address applications to: The Administrator, Armagh Observatory, College Hill, Armagh BT61 9DG, N. Ireland

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

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