COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

A Search for Photometric Rotation Periods in Low-Mass Stars and Brown Dwarfs in the Pleiades

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We have photometrically monitored (Cousins I_C) eight low mass stars and brown dwarfs which are probable members of the Pleiades. We derived rotation periods for two of the stars – HHJ409 and CFHT-PL8 – to be 0.258 d and 0.401 d, respectively. The masses of these stars are near 0.4 and 0.08 $M_\odot$, respectively; the latter is the second such object near the hydrogen-burning boundary for which a rotation period has been measured. We also observed HHJ409 in V; the relative amplitude in the two bands shows that the spots in that star are about 200 K cooler than the stellar effective temperature of 3560 K and have a filling factor on the order of 13%. With one possible exception, the remaining stars in the sample do not show photometric variations larger than the mean error of measurement. We also examined the M9.5V disk star 2MASSJ0149, which had previously exhibited a strong flare event, but did not detect any photometric variation.

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A Search for Radio Emission at the Bottom of the Main Sequence and Beyond

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We have used the VLA to conduct a deep search for 3.6 cm radio emission from nearby very low mass stars and brown dwarfs. The Güdel-Benz relation is used to predict radio luminosities for some very low mass stars and candidate brown dwarfs with measured X-ray fluxes. The predicted radio fluxes are quite small, whereas the measured radio flux from the brown dwarf candidate ρ Oph GY 31 is relatively strong. In light of our new observations, this object remains an anomaly. We present upper limits for our measured radio fluxes at 3.6 cm for our targets.

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Preliminary Results on the Circumstellar Envelopes of α Ori and R Leo from CO 4.6 μm Line Emission

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CO 4.6 μm vibration-rotational lines are detected in fluorescent emission from the inner regions of the Betelgeuse (α Orionis) and R Leonis stellar winds. The spatially and spectrally resolved 1-0 R(1), R(2), and R(3) line profiles are found to be highly useful probes of circumstellar shells. The current data sample only a few regions of the circumstellar shells of the program stars. However, now it should be possible to obtain envelope maps and absolute flux estimates, allowing new independent estimates of mass loss rates. This will open up new possibilities in the study of the structure and dynamics of stellar winds around red giants. The temperature 4" away from α Ori is found to be 38^{+6}_{-5} K. For R Leo the temperature 4" North is derived to be 24^{+3}_{-2} K and 4" South 35^{+7}_{-4} K.

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X–ray Emission from A0–F6 Spectral Type Stars

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We use the ROSAT public data archive to study the X–ray emission of a sample of supposedly single A0–F6 spectral type stars from the Bright Star Catalogue. We detected X–ray emission from 19 A– and 33 F–type stars. However, our results are not sufficient to associate with certainty the X–ray emission to the A–type stars themselves, since the usual argument that it may originate from a binary companion can not be excluded. A spectral analysis was conducted for 14 sources (3 A and 11 F), finding that for 12 of them a two temperature thermal plasma model is needed to reproduce the observed spectra. The two temperatures are centered at 0.13 and 0.54 keV, respectively. The values found for the higher temperature are lower than that ones of X–ray selected single late–type stars. The X–ray luminosities are in the range $L_X \sim 10^{28} - 10^{30}$ erg s^{-1}, with a distribution similar to that of active late–type stars. No correlation is found between L_X and B–V color, $V \sin i$ and L_{bol}, while a positive correlation is found between the X–ray luminosity and the hardness ratio.

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Lithium in Population I Subgiants

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We present a lithium survey for a sample of 91 Pop. I stars. $JHKL$ photometry was also obtained for 61 stars in the

sample. Besides Li abundances, [Fe/H] values were derived. Thanks to Hipparcos parallaxes, we could infer absolute V magnitudes for our sample stars and were able to place them on the color–magnitude diagram, which allowed us to constrain their evolutionary status. Masses and ages were derived for most of the stars by comparison with evolutionary tracks. The sample was originally selected so to include class IV stars later than spectral-type F0, but, based on the location on the color–magnitude diagram, we found *a posteriori* that a fraction of the stars (about 20 %) are either main sequence stars or evolved giants.

As it is the case for dwarfs and giants, a large spread in lithium abundance is present among the subgiants in our sample. As expected, the average lithium decreases as the stars evolve along the subgiant branch; however, there is not a one-to-one relationship between the position on the color–magnitude diagram and lithium abundance, and the observed dispersion is only partially explainable as due to a dispersion in mass, metallicity, and age. In particular, a dispersion in lithium is seen among slightly evolved subgiants with masses close to solar but in the same evolutionary stage as the G2 IV star β Hyi. The comparison of the β Hyi-like sample with a sample of non evolved solar–like stars indeed suggests that β Hyi has most likely evolved from a main sequence Li–rich star, rather than from a Li–poor star (like the Sun) that has dredged–up previously stored lithium.

Our sample includes several stars that have completed the first–dredge up lithium dilution, but that have not yet evolved to the evolutionary point where extra–mixing in the giant phase is thought to occur. A large number of them have Li abundances considerably below the theoretical predictions of first dredge–up dilution. We confirm that this is due to the fact that the progenitors of these stars are most likely stars that have depleted lithium while on the main sequence; the fraction of post–dredge up Li rich/poor stars, in fact, is consistent with the observed distribution of Li abundances among stars that have just left the main sequence.

The signature of the second mixing (or RGB extra–mixing) episode is evident in the log n(Li) vs. B$-$V and log n(Li) vs. $M_{\rm bol}$ distributions of the stars in the sample; it seems however that the extra–mixing occurs at luminosities lower than predicted by the models of Charbonnel (1994).

Finally, a few evolved giants are found that should have passed the second mixing episode, but that do not show signs of it. At least half of them are spectroscopic binaries.

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The Evolution of the Lithium Abundances of Solar Type Stars. IX. High-Resolution Spectroscopy of Low-Mass Stars in NGC 2264

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We have obtained Keck HIRES spectra of 35 objects in the pre-main sequence cluster NGC 2264 in order to determine their radial velocities, rotation rates, activity levels, and Li abundances. Our precise radial velocities indicate that the eight objects we observed that lie below a 5 Myr isochrone are non-members. This means the age spread within NGC 2264 is only about 4 Myr, a factor of two less than found previously, although this is a lower limit to the true age spread because star formation is still taking place in the cluster.

After correction for non-LTE effects, our Li abundances are consistent with no depletion having yet occurred and a uniform value of $\log N(\mathrm{Li}) = 3.2$, provided that the uncertainty in $T_{\rm eff}$ values is about 250 K. This is high, but this cluster appears to have varying extinction that could lead to large temperature errors.

Stars in NGC 2264 have spun up compared to the younger Orion Nebula Cluster. Current models suggest disk-locking timescales of 1 to 2 Myr to account for the most rapidly rotating stars. By combining rotation periods and $v \sin i$ values we show that the distribution of $\sin i$ is not in accord with a random distribution of rotation axes. The reason for this is not known, but is probably due to a selection against equator-on objects that still have obscuring material around them.

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Isotopic Lithium Abundances in Five Metal-poor Disk Stars

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High resolution ($R \simeq 110\,000$), very high S/N spectra centered on the 6707.8 Å LiI line have been obtained with the ESO Coudé Echelle Spectrometer for five, metal-poor ($-0.8 <$ [Fe/H] < -0.6) disk stars in the turnoff region of the HR-diagram. The instrumental and stellar atmospheric line broadening have been determined from two unblended iron lines and used in a model atmosphere synthesis of the profile of the LiI line as a function of the lithium isotope ratio. This has led to a detection of ^{6}Li in HD 68284 and HD 130551 with ^{6}Li/^{7}Li $\simeq 0.05$, whereas the other stars, HR 2883, HR 3578 and HR 8181, have ^{6}Li/^{7}Li close to zero.

By comparing T_{eff}-values and absolute magnitudes based on Hipparcos parallaxes with recent stellar evolutionary tracks, the masses of the stars have been derived. It is shown that the two stars with ^{6}Li present have a significantly higher mass, $\mathcal{M}/\mathcal{M}_\odot \simeq 1.05$, than the other three stars for which values between 0.85 and 1.0 $\mathcal{M}_\odot$ are obtained.

The results are discussed in terms of models for the galactic evolution of the light elements and depletion of the lithium isotopes in stellar envelopes. It is shown that the measured ^{6}Li abundances are in agreement with standard cosmic ray production of ^{6}Li in the galactic disk and a moderate depletion (0.5 dex) in the stars. Recent models for the evolution of ^{6}Li including $\alpha + \alpha$ fusion reactions and predicting a high lithium isotopic ratio, ^{6}Li/^{7}Li$\simeq 0.3$ at [Fe/H]$= -0.6$, require a high degree of ^{6}Li depletion ($\simeq 1.0$ dex) to fit the observations. Furthermore, these models imply a ^{7}Li abundance about 0.2 dex higher than observed for metal-poor disk stars.

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A Search for Variability in Brown Dwarfs and L Dwarfs

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We have undertaken a differential photometric I band search for variability in three Pleiades brown dwarfs and three very low mass field L dwarfs. Analysis of the resultant time series for the Pleiades brown dwarfs (Teide 1, Calar 3, Roque 11) gives no evidence for variability (above 99% confidence) greater than 0.05 mags in any of these objects on timescales between 25 minutes and 27 hours. Time series of two of the L dwarfs, 2MASSW J0913032+184150 and 2MASSW J1146345+223053, are also consistent with no intrinsic variability (no significant variability above 0.07 mags for 30 mins $< \tau <$ 126 hours, and above 0.025 mags for 30 mins $< \tau <$ 75 hours, for the two objects respectively). However, the L dwarf 2MASSW J1145572+231730 shows evidence for variability of amplitude 0.04 magnitudes with a tentative period of about 7 hours. It is therefore interesting that Kirkpatrick et al. (1999) report an Hα emission line of 4.2Å equivalent width for this star: If our detection is confirmed as a rotation period, it would support the link between rotation and Hα emission in very low mass stars.

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Solar Abstracts

Flux Pile-Up Magnetic Reconnection in Reduced MHD

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The rate of two-dimensional flux pile-up magnetic reconnection is known to be severely limited by gas pressure in a low-beta plasma of the solar corona. As earlier perturbational calculations indicated, however, the pressure limitation should be less restrictive for three-dimensional flux pile-up. In this paper the maximum rate of reconnection is calculated in the approximation of reduced magnetohydrodynamics (RMHD), which is valid in the solar coronal loops. The rate is calculated for finite-magnitude reconnecting fields in the case of a strong axial field in the loop. Gas pressure effects are ignored in RMHD but a similar limitation on the rate of magnetic merging exists. Nevertheless, the magnetic energy dissipation rate and the reconnection electric field can increase by several orders of magnitude as compared with strictly two-dimensional pile-up. Though this is still not enough to explain the most powerful solar flares, slow coronal transients with energy release rates of order $10^{25} - 10^{26}$ erg/s and heating of quiet coronal loops are within the compass of the model.

Accepted by Solar Physics

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Ph.D. Thesis Abstract

Magnetic Activity in Late-type Stars

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Ph.D dissertation directed by: Andrew Collier Cameron

Ph.D degree awarded: July 1999

High resolution spectroscopic techniques are used to investigate the magnetic topology of the young, rapidly rotating star, AB Dor.

Doppler images of AB Dor are produced using the Li I 6708 Å line and compared to images produced using Ca I and Fe I lines. A Li abundance of 2.9 $\pm$ 0.3 dex is measured using LTE profile synthesis. By evaluating the effects of enhanced spot Li abundances we find that starspots are unlikely to lead to an overestimation of the photospheric Li abundance. While the Li I 6708 Å line is strengthened in the presence of starspots, the extent to which the Li line equivalent width displays rotational modulation is diluted.

A Zeeman Doppler imaging code, which maps the surface magnetic flux distributions on rapid rotators, has been developed and tested in this thesis. Reliability tests indicate that this technique is robust with respect to small errors in line and stellar parameters.

Spectropolarimetric observations of AB Dor from three years are presented here. The technique of least squares deconvolution, combines the signal from over 1500 lines, enhancing the S/N of the observed dataset.

Brightness and magnetic maps of AB Dor are reconstructed using the deconvolved profiles and show excellent agreement with maps produced using independently developed codes by J.-F. Donati. This points to the consistency of Doppler imaging techniques. Magnetic field maps show the presence of strong radial and azimuthal fields at almost all latitudes. This non-solar like distribution of magnetic flux may indicate the presence of a distributed dynamo component operating in the convection zones of rapid rotators.

By tracing the positions of absorption transients in Hα, we find prominence complexes at almost all longitudes. Footpoint locations remain difficult to ascertain. Prominences are ejected over much shorter timescales than the timescale over which differential rotation should act. Further observations with closer time sampling are necessary to investigate the coronal topology further.

Thesis-related Publications: MNRAS, 288, 343; MNRAS, 302, 437

Upcoming Conference

Darwin and Astronomy: the Infrared Space Interferometer (IRSI)

November 17 - 19, 1999
Stockholm, Sweden

Organisers: Swedish National Space Board (SNSB), European Space Agency (ESA) and Stockholm Observatory

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This is the first announcement for the conference 'Darwin and Astronomy - the Infrared Space Interferometer' to be held in Stockholm, Sweden, from November 17 to 19, 1999. The conference is organised by the Swedish National Space Board (SNSB) and the European Space Agency (ESA), with support by Stockholm Observatory.

All relevant documentation regarding the conference, including electronic forms for registration and hotel reservations, can be found on the web at

http://www.astro.su.se/∼index.html

Purpose of this conference:

- To identify the most profound questions in the fields of modern astrophysics that can be adressed with a space-based interferometer working from 5 to 25 μm with baselines of up to 500 m and much more sensitive than ground-based instruments.

- To provide insights into the optimisation of the design of the instrument in the light of those questions.

It is envisaged that 30% of the time of the ESA candidate space mission for the Darwin infrared space interferometer will be devoted to general astrophysics. While much of the design will driven by its primary aim of extrasolar planetary systems studies, the astrophysical aims will also be important factors in the design.

This conference will start from a description of the present Darwin concept and its performance in different astrophysical observations. The inputs from participants in this conference will then constitute an important driving mechanism for the development of design characteristics of the instrument.

If you want to understand the prospects for space infrared interferometer astronomy or if you want to affect the design of Darwin so it can address your needs, you should attend this conference.

Topics and invited speakers include:
Galaxies and their Evolution Andrew Wilson (confirmed),
Active Galactic Nuclei/GC Reinhard Genzel (confirmed),
Observational Cosmology Malcolm Longair (tbc),
Supernovae (and Cosmology) Jason Spyromilio (tbc),
AGB and Related Phases of Stellar Evolution Hans Olofsson (confirmed),
Star Formation and Early Stellar Evolution Stephen Strom (confirmed),
Planet Formation and Disk Evolution Pawel Artymowicz (confirmed),
Physics of Planets Tristan Guillot (confirmed),
Planetology and Zodiacal Light Jane Luu (confirmed),
Astrobiology Baruch Blumberg (tbc),
Planets and Life Tobias Owen (tbc),
Origin of Life André Brack (confirmed),
Nulling Interferometry Neville Woolf and Bertrand Mennesson (confirmed),
Darwin - the Infrared Space Interferometer Malcolm Fridlund (confirmed),
TPF - the Terrestial Planet Finder Chas Beichman (confirmed),
GAIA - the Global Astrometric Interferometer for Astrophysics Lennart Lindegren (confirmed),
NGST - the Next Generation Space Telescope Peter Jakobsen (confirmed),

VLTI - the Very Large Telescope Interferometer Francesco Paresce (confirmed),
ALMA - the Atacama Large Millimeter Array Roy Booth (tbc)

Scientific Organising Committee: R. Genzel (chair), R. Liseau (co-chair), G. Arrhenius, C. Beichman, A. Brack, F. Capaccioni, C. Eiroa, M. Fridlund, T. Herbst, A. Léger, L. Nordh, A. Penny, D. Queloz, H. Roettgering, S. Volonte

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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, or M) 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` .