COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 86 — March 2003 Editor: Steve Skinner (coolnews@jila.colorado.edu)

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Editor's Note: April Mailing Unlikely

Due to travel and lack of computer access, it is unlikely that I will be mailing out Coolnews in April. At present, the next issue is planned for mailing in early May, with abstracts due on April 30. If these plans change, I will send out a call for abstracts. Keep those abstracts coming.
Steve Skinner (ed.)

Stellar Abstracts

More Lead Stars

S. Van Eck[1], S. Goriely[1], A. Jorissen[1] and B. Plez[2]

[1] Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, C.P. 226, Boulevard du Triomphe, B-1050 Bruxelles, Belgium
[2] GRAAL, Université de Montpellier II, cc 072, F-34095 Montpellier Cedex 05, France

The standard model for the operation of the s-process in asymptotic giant branch (AGB) stars predicts that low-metallicity ([Fe/H] ≤ -1) AGB stars should exhibit large overabundances of Pb and Bi as compared to other s-elements. The discovery of the first three such 'lead stars' (defined as stars enriched in s-elements with [Pb/hs] ≥ 1, hs being any of Ba, La or Ce) among CH stars has been reported in a previous paper (Van Eck et al., Nature 2001, 412, 793). Five more CH stars (with [Fe/H] ranging from -1.5 to -2.5) are studied in the present paper, and two of them appear to be enriched in lead (with [Pb/Ce]$\simeq 0.7$). The Pb I line at λ4057.812 Å is detected and clearly resolved thanks to high-resolution spectra ($R = \lambda/\Delta\lambda = 135000$). The abundances for these two stars (HD 198269 and HD 201626) are consistent with the predictions for the s-process operating in low-metallicity AGB stars as a consequence of the 'partial mixing' of protons below the convective hydrogen envelope. Another two stars (HD 189711 and V Ari) add to a growing number of low-metallicity stars (also including LP 625-44 and LP 706-7, as reported by Aoki et al., 2001, ApJ 561, 346) which do not conform to these predictions, however. Variations on the canonical proton-mixing

scenario for the operation of the s-process in low-metallicity stars, that could account for these discrepant stars, are briefly discussed.

Accepted by Astronomy and Astrophysics

For preprints contact: svaneck@astro.ulb.ac.be

For preprints via ftp or WWW: http://www-astro.ulb.ac.be/~svaneck/publi.html

Separating the X-Ray Emissions of UV Ceti A and B with *Chandra*

Marc Audard[1], Manuel Güdel[2], and Stephen L. Skinner[3]

[1] Columbia Astrophysics Laboratory, Mail Code 5247, 550 West 120th Street, New York, NY 10027, USA
[2] Paul Scherrer Institut, Würenlingen & Villigen, 5232 Villigen PSI, Switzerland
[3] Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80309-0389, USA

We present the first spatially separated X-ray observation of the active UV Ceti binary with *Chandra*, providing important new information on the relative X-ray activity levels of its nearly identical dM5.5e components. The two components had similar X-ray luminosities during low-level periods and emission measure loci derived from Low Energy Transmission Grating spectra reveal similar coronal temperatures ($3-6$ MK). However, the B component showed a higher degree of variability, resulting in a higher average X-ray luminosity than that of UV Cet A. We discuss possible causes of this enhanced activity in UV Ceti B.

Accepted by the Astrophysical Journal

For preprints contact: audard@astro.columbia.edu

Spectroscopic Abundances of Solar Type Dwarfs in Open Cluster M34 (NGC 1039)

Simon C. Schuler[1], Jeremy R. King[1], Debra A. Fischer[2], David R. Soderblom[3], and Burton F. Jones[4]

[1] Dept. of Physics, Univ. of Nevada, Las Vegas, 4505 Maryland Parkway, Las Vegas, NV 89154 USA
[2] Dept. of Astronomy, 601 Campbell Hall, Univ. of California at Berkeley, Berkeley, CA 94720 USA
[3] Space Telescope Science Institute, 3700 San Martin Dr., Baltimore, MD 21218 USA
[4] UCO/Lick Observatory, Dept. of Astronomy and Astrophysics, Univ. of California, Santa Cruz, 1156 High St., Santa Cruz, CA 95064 USA

Parameters and relative abundances of Fe, Ni, Ti, Cr, Ca, Si, Al, and Mg have been derived for nine M34 G and K dwarfs from high-resolution, modest S/N, Keck/HIRES spectra. Effective temperatures have been derived spectroscopically and fall in the range $4750 \leq T_{\rm eff} \leq 6130$ K. Despite modest scatter in Fe, Ti, Cr, Ca, Al, and Mg (none of which is found to be correlated with Li scatter in M34), our two coolest stars are slightly though consistently underabundant in these elements relative to the warmer stars. The two cool stars are slightly overabundant in Si, whose abundances are derived from higher excitation lines. This and our finding that Fe II-based abundances are significantly higher than Fe I-based values in the cool stars seems to point towards the action of NLTE effects (overionization and/or overexcitation), though additional analysis is required to exclude inadequacies in the model atmospheres. Final mean cluster abundances are based on five warm stars, which indicate $[\mathrm{Fe/H}] = +0.07 \pm 0.04$, and are void of any statistically significant scatter. The other elements scale well with Fe, except for Ni, which appears to be slightly underabundant with respect to Fe. K abundances are derived and show a surprising marked trend with temperature, which further supports our suspicion of the presence of NLTE effects. Moreover, similar trends with temperature suggest the Li and K underabundances in cool M34 dwarfs are partially related; thus, some portion of the well-known Li-$T_{\rm eff}$ trend in cool M34 dwarfs may be illusory.

Accepted by AJ

For preprints contact: sschule@ces.clemson.edu

Time Evolution of X-ray Coronal Activity in PMS stars; A Possible Relation with the Evolution of Accretion Disks

E. Flaccomio[1], G. Micela[1] and S. Sciortino[1]

[1]INAF - Osservatorio Astronomico di Palermo Giuseppe S. Vaiana, Palazzo dei Normanni, I-90134 Palermo, Italy

We investigate the evolution of X-ray stellar activity from the age of the youngest known star forming regions (SFR), < 1Myr, to about 100 Myr, i.e. the zero age main sequence (ZAMS) for a $\sim 1M_{\odot}$ star. We consider five SFR of varying age (ρ Ophiuchi, the Orion Nebula Cluster, NGC 2264, Chamaeleon I, and η Chamaeleontis) and two young clusters (the Pleiades and NGC 2516). Optical and X-ray data for these regions are retrieved both from archival observations and recent literature, and reanalyzed here in a consistent manner so to minimize systematic differences in the results.

We study trends of $L_{\rm X}$ and $L_{\rm X}/L_{\rm bol}$ as a function of stellar mass and association age. For low mass stars ($M < 1M_{\odot}$) we observe an increase in $L_{\rm X}/L_{\rm bol}$ in the first 3-4 Myr and a subsequent leveling off at the *saturation* level ($L_{\rm X}/L_{\rm bol} \sim -3$). Slowly evolving very low mass stars then retain saturated levels down to the oldest ages here considered, while for higher mass stars activity begins to decline at some age after $\sim 10^7$ years.

We find our data consistent with the following tentative picture: low mass PMS stars with no circumstellar accretion disk have saturated activity, *consistently* with the activity-Rossby number relation derived for MS stars. Accretion and/or the presence of disks somehow lowers the observed activity levels; disk dissipation and/or the decrease of mass accretion rate in the first few Myrs of PMS evolution is therefore responsible for the observed increase of $L_{\rm X}/L_{\rm bol}$ with time.

Accepted by A&A

For preprints contact: ettoref@oapa.astropa.unipa.it

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[*Editor's Note*: The above abstract is being cross-listed in the *Star Formation Newsletter* and is included here since evolution is followed down to the main sequence.]

Asterospheric Magnetic Fields and Winds of Cool Stars

Carolus J. Schrijver[1], Marc L. DeRosa[1], and Alan M. Title[1]

Lockheed Martin Advanced Technology Center (L9-41/252) 3251 Hanover Street, Palo Alto, CA 94304-1141

This study addresses the winds and magnetic fields in the inner asterospheres of Sun-like magnetically active stars, by combining empirical relationships between rotation rate and mass loss, angular-momentum loss, and radiative losses, with models of the magnetic fields at the surfaces of cool stars and in their inner asterospheres, based on the solar example. Our models, for mean magnetic flux densities up to 10× solar, suggest that the asterospheric fields of such stars are dominated by the large-scale dipole component of the surface field, as is the case for the Sun. Hence, most of the time a single current sheet is expected to separate domains of opposite magnetic polarity; the current sheets of more active stars generally have smaller latitudinal ripples. Magnetic braking requires that the total unsigned asterospheric magnetic flux increases linearly with the stellar angular velocity, which is a very much weaker increase than seen for the flux at the stellar surface. We show that this can be achieved by an increase in the radial distance at which the coronal field is forced open as surface activity increases. Combined with measured mass loss rates and the assumption that the wind velocity is largely independent of activity, this requires the wind's Alfvén radius to nearly constant, decreasing with surface activity with a power of only -0.16 ± 0.13. We point out that the surface flux density of energy needed to drive a cool-star wind scales linearly with the unsigned surface magnetic flux density, as does that needed to heat the corona.

Accepted by ApJ

For preprints contact: schryver@lmsal.com

For preprints via ftp or WWW: http://www.lmsal.com/~schryver/Public/ms/sdt2003.pdf

Stellar Kinematic Groups II. A Re-Examination of the Membership, Activity, and Age of the Ursa Major Group

J.R. King[1], A.R. Villarreal[2], D.R. Soderblom[3], A.F. Gulliver[4], and S.J. Adelman[5]

[1] Dept. of Physics & Astronomy, 118 Kinard Lab, Clemson University, Clemson, SC 29634
[2] Dept. of Physics, 1118 E. 4th St, University of Arizona, Tucson, AZ 85721
[3] STScI, 3700 San Martin Drive, Baltimore, MD 21218
[4] Dept. of Physics, Brandon University, Brandon, MB R7A 6A9, Canada
[5] Dept. of Physics, The Citadel, 171 Moultrie St, Charleston, SC 29409

We revisit the Ursa Major moving group membership status of some 220 stars to produce a final clean list of nearly 60 assured members based on kinematic and photometric criteria. Scatter in the velocity dispersions and H-R diagram is correlated with trial activity-based membership assignments. Closer inspection, however, shows that activity is considerably more robust at *excluding* membership, failing to do so only for $\leq$15% of objects, and perhaps considerably less. Our UMa members demonstrate non-zero vertex deviation in the Bottlinger diagram, behavior seen in older and recent studies of nearby young disk stars and perhaps related to Galactic spiral structure. Comparison of isochrones and our final UMa group members indicates an age of 500$\pm$100 Myr, some 200 Myr older than the canonically-quoted UMa age. Our UMa kinematic/photometric members' mean chromospheric emission levels, rotational velocities, and scatter therein are indistinguishable from values in the Hyades and smaller than evinced by members of the younger Pleiades and M34 clusters, suggesting these characteristics decline rapidly with age over 200-500 Myr. None of our UMa members demonstrate inordinately low absolute values of chromospheric emission, but several may show residual fluxes a factor of $\geq$2 below a Hyades-defined lower envelope. If one defines a Maunder-like Minimum in a *relative* sense, then the UMa results may suggest that solar-type stars spend 10% of their entire main-sequence lives in periods of precipitously low activity– consistent with estimates from older field stars. As related asides, we: note six evolved stars (among our UMa non-members) with distinctive kinematics and lying along a 2 Gyr isochrone that appear to be late-type counterparts to disk F-stars defining intermediate-age star streams in previous studies; identify a small number of potentially very young but isolated field stars; note that active stars (whether UMa members or not) in our sample lie very close to the solar composition zero-age main-sequence unlike Hipparcos-based positions in the H-R diagram of Pleiades dwarfs; and argue that some extant transformations of activity indices are not adequate for cool dwarfs, where Ca II infrared-triplet emission seems to be a better proxy than Hα-based values for Ca II H&K indices.

Accepted by AJ

For preprints contact: jking2@ces.clemson.edu

Stellar Coronal Astronomy – A Review

Fabio Favata[1], Giuseppina Micela[2]

[1] Astrophysics Division of ESA's Research and Science Support Department – P.O. Box 299, 2200 AG Noordwijk, The Netherlands
[2] INAF – Osservatorio Astronomico G. S. Vaiana – Piazza Parlamento 1, 90134 Palermo, Italy

Coronal astronomy is by now a fairly mature discipline, with a quarter century having gone by since the detection of the first stellar X-ray coronal source (Capella), and having benefitted from a series of major orbiting observing facilities. Several observational characteristics of coronal X-ray and EUV emission have been solidly established through extensive observations, and are by now common, almost text-book, knowledge. At the same time the implications of coronal astronomy for broader astrophysical questions (e.g. Galactic structure, stellar formation, stellar structure, etc.) have become appreciated. The interpretation of stellar coronal properties is however still often open to debate, and will need qualitatively new observational data to book further progress. In the present review we try to recapitulate our view on the status of the field at the beginning of a new era, in which the high sensitivity and the high spectral resolution provided by *chandra* and *XMM-Newtown* will address new questions which were not accessible before.

Accepted by Space Science Reviews

For preprints contact: Fabio.Favata@rssd.esa.int

For preprints via ftp or WWW: ftp://astro.esa.int/pub/ffavata/Papers/ssr-preprint.pdf

Castor A and Castor B Resolved in a Simultaneous Chandra and XMM-Newton Observation

B. Stelzer[1] **and V. Burwitz**[2]

[1] Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy
[2] Max-Planck Institut für extraterrestrische Physik, Postfach 1312, D-85741 Garching, Germany

We present a simultaneous *Chandra* and *XMM-Newton* observation of the Castor sextett, focusing on Castor A and Castor B, two spectroscopic binaries with early-type primaries. Of the present day X-ray instruments only *Chandra* can isolate the X-ray lightcurves and spectra of Castor A and B (angular separation $\sim 4''$). We compare the *Chandra* observation with *XMM-Newton* data obtained simultaneously. Albeit not able to resolve Castor A and Castor B from each other, the higher sensitivity of *XMM-Newton* allows for a quantitative analysis of their combined high-resolution spectrum. He-like line triplets are used to examine the temperature and the density in the corona of Castor AB. The temporal variability of Castor AB is studied using data collected with the European Photon Imaging Camera onboard *XMM-Newton*. Strong flare activity is observed, and combining the data acquired simultaneously with *Chandra* and *XMM-Newton* each flare can be assigned to its host. Our comparison with the conditions of the coronal plasma of other stars shows that Castor AB behave like typical late-type coronal X-ray emitters supporting the common notion that the late-type secondaries within each spectroscopic binary are the sites of the X-ray production.

Accepted by A&A

For preprints contact: stelzer@astropa.unipa.it

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Solar Abstracts

Temporal Variability of the Flare Index (1966-2001)

A. Özgüç[1]**, T. Ataç**[1] **and J. Rybák** [2]

[1] Kandilli Observatory, Boğaziçi University, Cengelköy, Istanbul, Turkey
[2] Astronomical Institute, Slovak Academy of Sciences, 059 60 Tatranská Lomnica, The Slovak Republic

A brief description and the results of the temporal variability of the flare index over the epoch of almost 4 cycles (1966-2001) are presented. Using Fourier and wavelet transforms the long- and the intermediate-term periodicities in the daily flare index data for the total surface and for the northern and the southern hemispheres of the Sun are given in detail. A significant variability was found for all periods including the 150-days and 1.3 years. The wavelet transform results show that the occurrence of flare index power is highly intermittent in time. A comparison of the results of the Fourier transform and the time-period wavelet transform of the flare index time series has clarified the importance of different periodicities, whether they are or are not the harmonics of the basic ones, as well as the temporal location of their occurrence.

Accepted by Solar Physics

For preprints contact: ozguc@boun.edu.tr

Serendipitous Discovery of Seven New Southern L-dwarfs

T.R.Kendall[1], N. Mauron[2], M. Azzopardi[3] and K. Gigoyan[4]

[1] Centro de Astronomia e Astrofísica da Universidade de Lisboa, Observatório Astronómico de Lisboa, Tapada da Ajuda, 1349-018 Lisboa, Portugal
[2] Groupe d'Astrophysique, UMR-5024 CNRS, Place Bataillon, F-34095 Montpellier Cedex 05, France
[3] IAM, Observatoire de Marseille, 2 Place Le Verrier, 13248 Marseille Cedex 04, France
[4] 378433 Byukaran Astrophysical Observatory & Isaac Newton Institute of Chile, Armenian Branch, Ashtarak d-ct, Armenia

We report the discovery of seven hitherto unknown L-dwarfs found as a result of a spectroscopic search for distant AGB stars. Their far-red and near-infrared colours are very similar to known dwarfs of the same spectral type. One new object is among the ~30 brightest L-dwarfs, with K_s=12.12, and is nearby, ~ 20pc. Using low resolution spectroscopy from the Danish 1.54 m ESO telescope, spectral types in the range L0.5 – L5 are derived for these seven L-dwarfs by direct comparison to L-type standards taken from Kirkpatrick et al. (1999). Distances are determined from existing calibrations, and together with measured proper motions, yield kinematics for the seven new dwarfs consistent with that expected for the solar neighbourhood disk population.

Accepted by A&A

For preprints contact: tkendall@ifa.hawaii.edu or see astro-ph/0302344

Transition from L to T Dwarfs on the Color-Magnitude Diagram

Takashi Tsuji[1] and Tadashi Nakajima[2]

[1] Institute of Astronomy, School of Science, The University of Tokyo, Mitaka, Tokyo, 181-0015 Japan
[2] National Astronomical Observatory, Mitaka, Tokyo, 181-8588 Japan

The color-magnitude (CM) diagram of L and T dwarfs based on the recent astrometry data is fitted, reasonably well for the first time, to the CM diagram transformed from the theoretical evolutionary tracks via a single grid of nongray model photospheres accommodating dust cloud. This is achieved with the use of the unified cloudy models (UCMs; $700 \lesssim T_{\rm eff} \lesssim 2600$ K), in which dust forms at its condensation temperature $T_{\rm cond}$ but grows to be larger than the critical radius $r_{\rm cr}$ (where the Gibbs free energy of formation attains the maximum) at a slightly lower temperature which we referred to as the critical temperature $T_{\rm cr}$. Since only small dust grains ($r \lesssim r_{\rm cr}$) are in detailed balance with the ambient gaseous molecules and survive in the photosphere, a thin dust cloud is formed in the temperature range of $T_{\rm cr} \lesssim T \lesssim T_{\rm cond}$. Given that $T_{\rm cond}(\approx 2000\,{\rm K})$ is fixed by the thermochemical data, $T_{\rm cr}$ can be a measure of the thickness of the dust cloud and is determined to be $T_{\rm cr} \approx 1800\,{\rm K}$ from the red limit of the observed infrared color, which is redder for thicker dust cloud. Thus, the dust cloud forms deep in the photosphere with T as high as $1800 - 2000\,{\rm K}$ (and not in the cooler surface region) independently of $T_{\rm eff}$, and the dust cloud appears at the optically thin region ($\tau_{\rm Ross} < 1$) in L dwarfs whose $T_{\rm eff}$'s are relatively high while at the optically thick region ($\tau_{\rm Ross} \gtrsim 1$) in T dwarfs whose $T_{\rm eff}$'s are lower (note that $T \approx T_{\rm eff}$ at $\tau_{\rm Ross} \approx 1$). As a result, the dust cloud moves from the optically thin region in L dwarfs to the deeper optically thick region in T dwarfs. This migration of the dust cloud is directly mapped on the CM diagram; for example, the rapid bluing from the late L to the early T dwarfs is simply a result of the transition of the thin dust cloud from the optically thin ($\tau < 1$) to thick ($\tau \gtrsim 1$) regimes while $L_{\rm bol}$ and $T_{\rm eff}$ lower only slightly. A distinct brightening at the J band in the T 5 dwarf revealed by the recent parallax measurements is also explained as a natural consequence of the migration of the dust cloud to the inner region of the photosphere and should not necessarily be evidence for Burgasser et al.'s proposition that the dust cloud breaks up in the L/T dwarf transition. Thus, the theoretical evolutionary models, the cloudy models of the photospheres (UCMs), and the observed fundamental stellar parameters are brought into a consistent picture of the newly defined L and T dwarfs.

Accepted by ApJ Letters (March 10, 2003 issue)

For preprints contact: ttsuji@ioa.s.u-tokyo.ac.jp

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Ph.D. Thesis Abstracts

The Formation of Brown Dwarfs - Fundamental Properties of Very Young Objects Near and Below the Substellar Limit

Viki Joergens

e.g.: Thesis work conducted at: Max-Planck-Institute for Extraterrestrial Physics, Garching, Germany

know Current address: Max-Planck-Institute for Extraterrestrial Physics, Giessenbachstr.1, D-85748 Garching, Germany

E-mail: viki@mpe.mpg.de

Ph.D dissertation directed by: Prof. Dr. G. Morfill

Ph.D degree awarded: January 2003

A population of twelve very young bona fide and candidate brown dwarfs in the Cha I star forming cloud (Cha Hα 1–12) was studied observationally in terms of their kinematic properties, the occurrence of multiple systems among them as well as their rotational characteristics. Based on high-resolution spectra taken with UVES at the VLT, radial and rotational velocities have been measured with high accuracy. A kinematic study of the sample showed that their radial velocity dispersion is relatively small ($2.2\,\mathrm{km\,s^{-1}}$). It is significantly smaller than the radial velocity dispersion of the T Tauri stars in the field ($3.6\,\mathrm{km\,s^{-1}}$) and slightly larger than that one of the surrounding molecular gas ($1.2\,\mathrm{km\,s^{-1}}$). This result indicates that the studied brown dwarfs are not ejected during their formation with velocities large than $\sim 2\,\mathrm{km\,s^{-1}}$ as proposed in recent formation scenarios.The brown dwarfs may have larger 3D velocities. However, brown dwarfs ejected during the early accretion phase in directions with a significant fraction perpendicular to the line-of-sight, would have flown out of the field a long time ago.

By means of time-resolved UVES spectra, a radial velocity survey for close companions to the targets was conducted. In addition, a direct imaging survey for wide companions was carried out with the WFPC camera on board the HST, with FORS at the VLT as well as with SofI at the NTT. With these two complementary search methods, a wide range of possible companion separations has been covered. For brown dwarf companions ($> 13\,\mathrm{M_{Jup}}$) to the targets, separations < 3 AU and between 50 and 1000 AU were covered. With more restricted separations (< 0.1 AU and 300–1000 AU) the surveys were sensitive also to companion masses down to about $1\,\mathrm{M_{Jup}}$. HST images of Cha Hα 2 hint at a binary system comprised of two approximately equal-mass companions with a separation of $\sim$30 AU. No further indications for companions have been found in the images. Furthermore, the radial velocities of the targets turned out to be rather constant setting upper limits for the mass $\mathrm{M_2} \sin i$ of possible companions to $0.1\,\mathrm{M_{Jup}}$ to $2\,\mathrm{M_{Jup}}$. These findings hint at a rather low ($\leq 10\%$) multiplicity fraction of the studied brown dwarfs.

Furthermore, a photometric monitoring campaign of the targets yielded the determination of rotational periods for Cha Hα 2, Cha Hα 3 and Cha Hα 6 in the range of 2.2 to 3.4 days. These are the first rotational periods for very young brown dwarfs and among the first for brown dwarfs at all. They are complemented by measurements of rotational velocities $v \sin i$ from UVES spectra. The observations show that brown dwarfs at an age of 1–5 Myr display surface spots like T Tauri stars and are moderately fast rotators in contrast to rapidly rotating old brown dwarfs consistent with them being in an early contracting stage.

Thesis-related Publications: A&A 379, L9; A&A 384, 999

UPCOMING MEETING

Science with Adaptive Optics
ESO Workshop
September 16-19, 2003
Garching (near Munich), Germany

Over the past ten years, the concept of adaptive optics has matured from early experimental stages to a standard observing tool now available at many large optical and near-infrared telescope facilities. Indeed, adaptive optics has become an integral part of all present and future large telescope initiatives, and will be essential in exploiting the full potential of the large optical interferometers currently under construction. Adaptive optics has been identified as one of the key technologies for astronomy in the 21st century. Adaptive optics has already delivered exciting results covering areas from solar system astronomy (both the sun and the planetary system) over the star forming regions in the solar neighbourhood to Local Group galaxies and objects at cosmological distances. Recent highlights include:

- Evolution of small scale structures on the solar surface
- Discovery of binary asteroids and asteroids moons
- High-resolution studies of circumstellar disks around young stars
- Precise mass determination of the black hole in the Galactic Center
- Spatially resolved studies of extragalactic stellar populations

The present meeting intends to bring together users of adaptive optics from all fields of astronomy to discuss the latest scientific results obtained with diverse adaptive optics systems and to exchange ideas on how to reduce and analyse such observations. This ESO workshop aims also at educating the general astronomical community in Europe on the unique science potential of adaptive optics for all branches of astronomy. We want to bring together researchers working in many different areas of astronomy in order to provide a comprehensive picture of the utilisation of adaptive optics in astronomy. Synergy effects are expected from the comparison of different observing and data analysis strategies.

Scientific Organizing Committee:
Co-chairs: Wolfgang Brandner (MPIA), Markus Kasper (ESO)
Danielle Alloin (ESO), Laird Close (Steward Obs., Tucson, USA), Tim Davidge (Herzberg Inst., Victoria, Canada), Reinhard Genzel (MPE, Germany), Thomas Henning (MPIA, Germany), Christoph Keller (NSO Tucson, USA), Anne-Marie Lagrange (LAOG, France), Simon Morris (Durham, UK), Francois Rigaut (Gemini, USA), Daniel Rouan (Obs. de Paris, France), Hans Zinnecker (AIP, Germany)

For more details and registration, see **http://www.eso.org/aoscience03**

Symposium Secretary: Christina Stoffer

European Southern Observatory
Karl-Schwarzschild-Str. 2
D-85748 Garching bei München, Germany
FAX: +49 89 3200 6480
email: aoscience03@eso.org

UPCOMING MEETING

First Announcement
IAU Symposium (proposed): CORONAL AND STELLAR MASS EJECTIONS
September 13-17, 2004
Beijing, China

The goal of this meeting will be to discuss and summarize the latest research on coronal and stellar mass ejections. Both invited and contributed presentations will be included in the scientific program which will cover the following main topics:

1. Observed properties of CMEs 2. Source regions (magnetic and coronal structure) 3. Theoretical models of CMEs 4. Comparisons of theories and observations 5. ICMEs in the heliosphere 6. CMEs and energetic particles 7. CMEs and geomagnetic storms 8. Stellar ejecta

The scientific organizing and advisory committee consists of

K. Dere (USA, co-chair) J. Wang (China, co-chair) S. Antiochos (USA) R. Howard (USA) V. Bothmer (Germany) H. Hudson (USA) J.-L. Bougeret (France) S. Kahler (USA) A. Cameron (UK) D. Reames (USA) H. Cane (Australia) R. Schwenn (Germany) I. Chertok (Russia) K. Shibata (Japan) C. Fang (China) S. Solanki (Germany) T. Forbes (USA) B. Tsurutani (USA) R. Harrison (UK) P. Venkatakrishnan (India)

If you are interested in receiving further information on this meeting in the future, please visit our web page:

http://lasco-www.nrl.navy.mil/~avourlid/cme_mtg

Use the email link to provide us with your email address so that we can send you future announcements.

Ken Dere
Code 7663, Naval Research Laboratory
Washington, DC 20375 USA

dere@halcyon.nrl.navy.mil

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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*** Please send abstracts in the body of the message and *not* as attachments.***