COOLNEWS

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Stellar Abstracts

Chromospherically Active Stars. XXIII. The Triple System HD 7205 = QU Andromedae

Francis C. Fekel[1]

[1] Tennessee State University, Center of Excellence in Information Systems, 330 10th Ave. North, Nashville, TN 37203 USA

HD 7205 is a recently discovered visual binary. The primary star is a chromospherically active, single-lined binary, making the system triple. From spectroscopic observations, the orbit of the primary has a period of 18.01335 days and a moderate eccentricity of 0.197. The primary's spectral type is G8 IV-V. The unseen secondary of the short-period binary is likely an M dwarf, while the visual binary secondary is probably a K3 dwarf. From solar-abundance evolutionary tracks, the primary has a mass of ∼1.0 solar mass and an age of about 10 billion years. It has evolved off the main sequence and is approaching the base of the red-giant branch. Its rotation period of 21.3 days is significantly different from its pseudosynchronous rotation period of 14.6 days, making it an asynchronous rotator.

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For preprints contact: fekel@evans.tsuniv.edu

Chromospheric Ca II Emission in Nearby F, G, K, and M stars

Jason T. Wright[1]**, Geoffrey W. Marcy**[1]**, R. Paul Butler**[2] **and Steve S. Vogt**[3]

[1] Dept. of Astronomy, 601 Campbell Hall, Univ. of California, Berkeley, CA 94720 USA
[2] Dept. of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road NW, Washington, DC 20015-1305 USA
[3] Univ. of California / Lick Observatory, Univ. of California at Santa Cruz, Santa Cruz, CA 95064 USA

We present chromospheric caii activity measurements, rotation periods and ages for ∼1200 F-, G-, K-, and M- type main-sequence stars from ∼ 18,000 archival spectra taken at Keck and Lick Observatories as a part of the California and Carnegie Planet Search Project. We have calibrated our chromospheric S values against the Mount Wilson chromospheric activity data. From these measurements we have calculated median activity levels and derived rphk, stellar ages, and rotation periods for 1228 stars, ~1000 of which have no previously published S values. We also present precise time series of activity measurements for these stars.

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For preprints contact: jtwright@astro.berkeley.edu

For preprints via WWW: `http://astro.berkeley.edu/~jtwright/CaIIdata/`

A Multi-Wavelength Perspective of Flares on HR 1099: Four Years of Coordinated Campaigns

R. A. Osten[1], A. Brown[2], T. R. Ayres[2], S. A. Drake[3], E. Franciosini[4], R. Pallavicini[4], G. Tagliaferri[5], R. T. Stewart[6], S. L. Skinner[2], & J. L. Linsky[7]

[1] National Radio Astronomy Observatory, Charlottesville, VA 22903 USA
[2] Center for Astrophysics and Space Astronomy, Univ. of Colorado, Boulder, CO 80309-0389 USA
[3] HEASARC, NASA/GSFC, Greenbelt, MD 20771 USA
[4] INAF/Osservatorio Astronomico di Palermo, Italy
[5] INAF/Osservatorio Astronomico di Brera, Italy
[6] Australia Telescope National Facility, Australia
[7] JILA, Campus Box 440, Univ. of Colorado, Boulder, CO 80309-440 USA

We report on four years of multiple wavelength observations of the RS CVn system V711 Tau (HR 1099) from 1993, 1994, 1996 and 1998. This combination of radio, ultraviolet (UV), extreme ultraviolet (EUV), and X-ray observations allows us to view, in the most comprehensive manner currently possible, the coronal and upper atmospheric variability of this active binary system. We report on the changing activity state of the system as recorded in the EUV and radio across the four years of observations, and study the high energy variability using an assemblage of X-ray telescopes. We find:
(1) evidence for coherent emission at low radio frequencies ($\leq$ 3 GHz) which appears to be both highly time variable and persistent for several hours. Such phenomena are relatively common, occurring $\approx$ 30% of the time HR 1099 was observed at L-band. The measured polarizations of these bursts are left circularly polarized, in contrast with behavior at higher frequencies which has the opposite helicity. The polarizations are consistent with a variable source that is 100% left circularly polarized, along with a steady level of flux and polarization which is 0 or slightly right circularly polarized. There appears to be a low degree of correlation between bursts at 20 cm and higher frequency gyrosynchrotron flares, and also between 20 cm bursts and large EUV/soft X-ray (SXR) outbursts.
(2) Higher frequency (5–8 GHz) flares show an inverse relationship between flux and polarization levels as the flare evolves; this behavior is consistent with flare emission which is initially unpolarized. Large variations in spectral index are observed, suggesting changes in optical depths of the flaring plasma as the burst progresses. Quiescent polarization spectra show an increase of polarization with frequency, a pattern typically seen in active binary systems but still not understood.
(3) EUV observations reveal several large flares, in addition to numerous smaller enhancements. The total range of variability as gleaned from light curve variations is only a factor of 7, however. Observations in different years provide evidence of a change in the quiescent, not obviously flaring, luminosity, by a factor of up to 2. From an analysis of time-resolved spectral variations, we are able to infer evidence for the creation of high-temperature plasma during flare intervals compared with quiescent intervals. Interpretation of EUV spectral variations is hindered by the lack of ability to diagnose continuum levels and activity-related abundance changes, which are known from higher energy observations. Electron densities determined by line ratios of density-sensitive emission lines are high (10^{12}–10^{13} cm^{-3}) and there is no evidence for large density enhancements during flare intervals, compared with quiescent intervals.
(4) X-ray observations reveal several flares, and provide evidence of energy-dependent flare evolution: harder X-ray energies show faster temporal evolution than at softer energies. Time-resolved X-ray spectral analysis shows the presence of hot plasma, $T_e \sim 30$ MK, during flares compared to quiescent intervals, as well as evidence for changing abundances during flares. The abundance of iron (which is subsolar) shows an enhancement of a factor of three at the peak of a moderate flare seen by *ASCA* relative to the pre-flare level; abundances decrease during the flare decay. No hard (> 15 keV) emission is detected by either *RXTE* or *BeppoSAX*.
(5) The luminosity ratios L_{EUV}/L_R in quiescence determined from several time intervals during the four campaigns

are consistent with previously determined ratios from a sample of active stars and solar flares. The range of L_{EUV}/L_R from three EUV/radio (3.6 cm) flares is the same as the values obtained during quiescence, which points to a common mechanism for producing both flaring and not flaring emission.
(6) Seventeen flares were observed in the EUV and/or SXR during the four campaigns; of the eight flares that had radio coverage, three show 3.6 cm radio flares, which are generally consistent with the Neupert effect. Five EUV/SXR flares had partial UV coverage; all show UV responses, particularly in the C IV transition. The UV flare enhancements can occur at the same time as the 3.6 cm radio flares, in two cases where radio, UV, and EUV/SXR flare coverage overlapped.
(7) For SXR flares, we find that the contrast between flare emission and quiescent emission increases as expected towards higher energies, making flare detections easier at harder X-ray energies. This is due to the creation of high temperature plasma during flares, which shows up predominantly in high energy continuum emission. We find a discrepancy between the implied flaring rate based on EUV observations, and higher energy observations; the lower energies tend to miss many of the flares, due to the lack of sufficient contrast with quiescent emission.

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For preprints contact: rosten@nrao.edu

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High Resolution X-ray Spectroscopy of the Post-T Tauri Star PZ Tel

C. Argiroffi[1], J.J. Drake[2], A. Maggio[3], G. Peres[1], S. Sciortino[3] and F.R. Harnden[2]

[1] Dipartimento di Scienze Fisiche ed Astronomiche, Sezione di Astronomia, Università di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy
[2] Smithsonian Astrophysics Observatory, 60 Garden Street, Cambridge, MA 02138
[3] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy

We present an analysis of the *Chandra* High Energy Transmission Grating Spectrometer observation of the rapidly rotating ($P_{\rm rot} = 0.94$ d) post T Tauri (~ 20 Myr old) star PZ Telescopii, in the Tucana association. Using two different methods we have derived the coronal emission measure distribution, $em(T)$, and chemical abundances. The $em(T)$ peaks at $\log T = 6.9$ and exhibits a significant emission measure at temperatures $\log T > 7$. The coronal abundances are generally ~ 0.5 times the solar photospheric values that are presumed fairly representative of the composition of the underlying star. A minimum in abundance is seen at a first ionization potential (FIP) of 7-8 eV, with evidence for higher abundances at both lower and higher FIP, similar to patterns seen in other active stars. From an analysis of the He-like triplet of Mg XI we have estimated electron densities of $\sim 10^{12} - 10^{13}\,\mathrm{cm}^{-3}$. All the coronal properties found for PZ Tel are much more similar to those of AB Dor, which is slightly older than PZ Tel, than to those of the younger T Tauri star TW Hya. These results support earlier conclusions that the soft X-ray emission of TW Hya is likely dominated by accretion activity rather than by a magnetically-heated corona. Our results also suggest that the coronae of pre-main sequence stars rapidly become similar to those of older active main-sequence stars soon after the accretion stage has ended.

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Positional Uncertainties and Detection Limits of ROSAT X-ray Sources

T. R. Ayres[1]

[1] Center for Astrophysics and Space Astronomy, 389 UCB, University of Colorado, Boulder, CO 80309

This study addresses, primarily, positional uncertainties of sources imaged by the X-ray cameras on the *Röntgensatellit* (*ROSAT*). Monte Carlo simulations are exploited to estimate the precision of centroiding point-source "photon clouds" in *ROSAT* event lists. Measurements of bright coronal stars demonstrate that the design specification $6''$ accuracy of a *ROSAT* pointing center was achieved in practice. Furthermore, the accuracy often can be improved to $2''$, or better, by matching serendipitous X-ray sources to an optical catalog like the U.S. Naval Observatory A2. Even a low-S/N detection usually can be localized well enough to obtain a unique identification with a cataloged object, or establish that no bright optical counterpart is present.

Secondarily, and in a more general context, the study addresses detection significance and flux limits in the sparse-counting regime. Building on previous work by Gehrels, and Kraft, Burrows, & Nousek, scaling laws are developed to estimate detection thresholds and lower and upper bounds on possible source fluxes. Although the specific application of *ROSAT* was in mind, the flux limit approximations apply to other situations governed by Poisson statistics; including ultraviolet and X-ray spectra with low source counts and non-negligible backgrounds.

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For preprints contact: ayres@casa.colorado.edu

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Solar Abstracts

Bifurcation of the Metric Type II Radio Emission Associated With the Giant Solar Flare of April 2, 2001

S. Mancuso[1] **and L. Abbo**[1]

[1] Istituto Nazionale di Astrofisica (INAF), Osservatorio Astronomico di Torino, Strada Osservatorio 20, Pino Torinese 10025, Italy

On April 2 2001, following one of the largest flares of the present solar cycle, intense and complex metric type II radio bursts were recorded by the Hiraiso Radio Spectrograph. Metric type II emission is a typical signature of the propagation of a coronal shock. The dynamic spectra of this event present a clear bifurcation of the radio emission lanes, which is very rare in the metric domain and requires a proper interpretation. We model this bifurcation as the result of the interaction of a piston-driven spherical shock with a vertical current sheet located above the active region where the X20 flare occurred. The geometry of the expanding transient and the coronal electron density, necessary to derive the type II dynamics, are constrained through analysis of data obtained from the Solar and Heliospheric Observatory (SOHO) instruments. The model replicates successfully the observed bifurcation, supporting our interpretation. Furthermore, we propose that magnetic reconnection was triggered in the current sheet by the shock passage.

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For preprints contact: mancuso@to.astro.it

Network Boundary Origins of Fast Solar Wind Seen in the Low Transition Region?

M. D. Popescu [1,2], **J. G. Doyle**[1] **and L. D. Xia**[1]

[1] Armagh Observatory, College Hill, Armagh BT61 9DG, N. Ireland
[2] Astronomical Institute of the Romanian Academy, RO-75212 Bucharest 28, Romania

We present a study of a high spatial resolution raster acquired on-disk with the SUMER (Solar Ultraviolet Measurements of Emitted Radiation) grating spectrograph on SoHO (the Solar and Heliospheric Observatory) in a polar Coronal Hole (CH) region. We analyse two EUV emission lines, representing the properties of solar plasma in the low transition region (TR), O III 703.87 Å (maximum electron temperature, $T_e \approx 8 \times 10^4$ K), as well as in the corona, Mg IX 706.02 Å ($T_e \approx 10^6$ K). For Mg IX, we find that low CH intensities correspond to negative Doppler velocities (outflows) of ≈ 5 km s^{-1}. Along the quiet Sun (QS)/CH boundaries, the coronal plasma begins to be more red-shifted. A coronal bright point (BP) located within the CH is blue-shifted in the coronal line. In the TR line, the outer region of the BP is red-shifted at ≈ 5 km s^{-1}, but, towards its middle, the shift is around zero. The O III line, although it shows predominant downward motion of ≈ 4 km s^{-1} in the CH and ≈ 5 km s^{-1} in the QS, it also has blue-shifts arranged in a small-scale network pattern with average negative values of 3.5 km s^{-1} in CH and 3 km s^{-1} in the QS. The blue-shifts are caused either by plasma outflows of a few km s^{-1}, or by transient events such as bi-directional jets which dislocate plasma to upward velocities even higher than 100 km s^{-1}. The outflows originate predominantly from the intersection between the magnetic network and the inter-network cells (network boundaries). The bi-directional jets are found along the CH/QS boundaries, and, moreover, in locations where the plasma seen in the Mg IX line is blue-shifted, but very close to small red-shifted regions. Another interesting change in behaviour is observed at the QS/CH boundaries, in the O III line, where plasma from the network changes its velocity sign, becoming red-shifted.

Our results constitute the lowest-in-altitude observed signature of plasma outflows from the chromospheric network boundaries inside a CH. We have derived this conclusion from direct correlation between Doppler velocity and the intensity of the O III 702.87 Å line.

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On the Formation of the Resonance Lines of Helium in the Sun

Anna Pietarila[1] and Philip G. Judge[2]

[1] High Altitude Observatory, National Center for Atmospheric Research,P.O. Box 3000, Boulder CO 80307-3000, USA. Previously at the Department of Physics, Lund University, Box 118, S-221 00 Lund, Sweden
[2] High Altitude Observatory, National Center for Atmospheric Research,P.O. Box 3000, Boulder CO 80307-3000, USA

To investigate the cause of anomalously bright resonance lines of helium in the Sun, we have studied the magnitude of the enhancements and some proposals made to explain them. Calculations in new semi-empirical solar models indicate that the resonance lines of helium are enhanced by factors of 2-5 for He I and between 2 and 9 for He II, depending on the elemental abundances assumed. These enhancements are substantially less than earlier work has suggested, the differences arising from radiative transfer not only in helium lines but also in lines of less abundant elements. Photon scattering, even with small line center optical depths (of order unity or less) throughout the transition region, is shown to modify significantly line intensities and their center-to-limb variation, having important consequences for analyses of emission lines including emission measure analyses. We have re-examined some proposals to explain the enhancements based on the "ionizing plasma" picture. The proposals include explicit heating (the "burst" picture) and heating via advection (diffusive and/or flowing models and the "velocity redistribution" [VR] proposal). We argue that the original VR mechanism must be modified to include kinetic effects for helium atoms, which reduce the effects of VR. The VR mechanism also naturally predicts helium lines which are blue-shifted relative to lines less sensitive to VR, which contradicts observations for the He I 584 Å line. Ionizing plasma models also potentially lead to enhancement of $\Delta n \geq 1$ transitions ($n=$ principal quantum number) in other atoms and ions. Existing observational evidence for enhanced $\Delta n \geq 1$ transitions in other ions is weak. We conclude that the ionizing plasma scenarios are not the sole cause of the helium enhancement. Instead, in a companion paper we propose that the thermodynamic properties of noble gases in the upper chromosphere will lead to enhancement of their spectral lines if cross-field diffusion into coronal plasma is important. Lastly, we show that multi-fluid flows of the kind computed by Fontenla and colleagues can surprisingly reproduce observed intensities of several lines of C and Si, and may contain a resolution to the helium enhancement problem.

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For preprints contact: annap@ucar.edu

On the Formation of EUV Helium Lines in the Sun: Analysis of *SOHO* data

Philip G.Judge[1] and Anna Pietarila[2]

[1] High Altitude Observatory, National Center for Atmospheric Research,P.O. Box 3000, Boulder CO 80307-3000, USA
[2] High Altitude Observatory, National Center for Atmospheric Research,P.O. Box 3000, Boulder CO 80307-3000, USA. Previously at the Department of Physics, Lund University, Box 118, S-221 00 Lund, Sweden.

The resonance lines of helium in the Sun are factors of several stronger than expected, relative to lines of other ions. To explore the origins of this "helium enhancement", we have studied data from the SUMER, CDS, MDI and EIT instruments on *SOHO*. Time series data obtained in a quiet region and a coronal hole indicate that the spatio-temporal properties of the He I 584 Å and He II 304 and 1084 Å lines are qualitatively unlike other chromospheric and transition region lines. Helium line intensities vary slowly in comparison to chromospheric oscillations and to transient transition region brightenings seen in other lines, yet they vary rapidly (both spatially and temporally) in comparison with the coronal radiation. This suggests that photoionization/recombination plays a minor excitation role in these lines. The Doppler shift of the 584 Å line shows a remarkably clear 4-8 mHz oscillation, with no accompanying line intensity oscillation. Transient brightenings are used to show that non-radial photon scattering might explain the previously found diffuse appearance of the network, but cannot account for the reduced network/internetwork intensity contrast, in the 584 Å line. We propose a new enhancement mechanism, based upon arguments in a companion paper, in which predominantly neutral species such as helium diffuse across magnetic field lines into regions of hot coronal plasma, but charged ions do not. The enhanced internetwork helium emission may arise from the diffusion of helium atoms across the chromospheric canopy, the enhanced network emission may have contributions from diffusion from spicules. This mechanism may naturally explain why the 584 Å line shows Doppler shift, but not intensity, oscillations. Lastly, if a mechanism such as "velocity redistribution" dominates helium emission, spectroheliograms of helium lines will be bright in regions of large temperature gradients parallel to the magnetic field. Differences between helium and other spectroheliograms may then reveal the relative contributions of "classical" and "cool loop" models to the observed emission.

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For preprints contact: annap@ucar.edu

Differential Rotation and Meridional Circulation Near the Boundaries of the Solar Convection Zone

L. L. Kitchatinov

Institute for Solar-Terrestrial Physics, P.O. Box 4026, Irkutsk, 664033, Russian Federation

Although the theory of differential rotation is in satisfactory agreement with helioseismological data for the deep convection zone, there are considerable discrepancies near the solar surface. This disagreement can be eliminated if the anisotropy of turbulent convection is taken into account together with the effects of inhomogeneity, on which the most recent models for differential rotation are based. The model for the differential rotation of the convection envelope is supplemented by computations for the transition layer between the nonuniform and rigid-body rotation in the upper layers of the solar radiative core. Thereby, the differential rotation is computed for the entire volume of the Sun.

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Low-Mass and Substellar Abstracts

Discovery of Very Nearby Ultracool Dwarfs from DENIS

T.R. Kendall[1], X. Delfosse[1], E.L. Martín[2] and T. Forveille[3]

[1] Laboratoire d'Astrophysique de Grenoble, Université Joseph Fourier, 38041 Grenoble Cedex 9, France
[2] Instituto de Astrofísica de Canarias, Via Láctea, E-38200 La Laguna, Tenerife, Spain
[3] CFHT Corporation, 68–1238 Mamalahoa Highway, Kamuela, HI 96743, USA

We report new spectroscopic results, obtained with UKIRT/CGS4, of a sample of 14 candidate ultracool dwarfs selected from the DENIS (Deep Near-Infrared Survey of the Southern Sky) database. A further object, selected from the 2MASS Second Incremental Release, was observed at a later epoch with the same instrument. Six objects are already known in the literature; we re-derive their properties. A further four prove to be very nearby (≤ 10 pc) mid-to-late L-dwarfs, three unknown hitherto, two of which are almost certainly substellar. These findings increase the number of L-dwarfs known within ~ 10 pc by $\sim 25\%$. The remainder of the objects discussed here are early L or very late M-type dwarfs lying between $\sim$45 and 15 pc and are also new to the literature. Spectral types have been derived by direct comparison with *J*-,*H*- and *K*- band spectra of known template ultracool dwarfs given by Leggett et al. (`ftp://ftp.jach.hawaii.edu/pub/ukirt/skl/dL.spectra/`) For the known objects, we generally find agreement to within $\sim$1 subclass with previously derived spectral types. Distances are determined from the most recent M_J vs. spectral type calibrations, and together with our derived proper motions yield kinematics for most targets consistent with that expected for the disk population; for three probable late M-dwarfs, membership of a dynamically older population is postulated. The very nearby L-type objects discussed here are of great interest for future studies of

binarity and parallaxes.

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For preprints contact: tim.kendall@obs.ujf-grenoble.fr

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Spectral Classification and Effective Temperatures of L and T Dwarfs Based on Near-Infrared Spectra

Tadashi Nakajima[1], Takashi Tsuji[2] and Kenshi Yanagisawa[3]

[1] National Astronomical Observatory, 2-21-1, Osawa, Mitaka 181-8588, Japan

[2] Institute of Astronomy, The University of Tokyo, 2-21-1, Osawa, Mitaka 181-0015, Japan

[3] Okayama Astrophysical Observatory, Kamogata, Okayama 719-0231, Japan

We have obtained near-infrared spectra of L dwarfs, L/T transition objects and T dwarfs using Subaru. Resulting spectra are examined in detail to see their dependence on spectral types. We have obtained bolometric luminosities of the objects with known parallaxes within our sample, first by integrating the spectra and second by K band bolometric correction. We derive the relation between the effective temperature and spectral type.

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2MASS J05185995−2828372: Discovery of an Unresolved L/T Binary

Kelle L. Cruz[1], Adam J. Burgasser[2], I. Neill Reid[3] and James Liebert[4]

[1] Department of Physics and Astronomy, University of Pennsylvania, 209 South 33rd Street, Philadelphia, PA 19104-6396 USA

[2] Division of Astronomy and Astrophysics, University of California at Los Angeles, Los Angeles, CA, 90095-1562 USA

[3] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218 USA

[4] Department of Astronomy and Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721 USA

We present the peculiar near-infrared spectrum of the newly discovered brown dwarf 2MASS J05185995−2828372, identified in the Two Micron All Sky Survey. Features characteristic of both L and T dwarfs are present, namely, strong carbon monoxide absorption in the K band, strong methane absorption in the J and H bands, and red near-infrared colors. We consider several scenarios that could produce these features and conclude that the object is most likely to be an unresolved L/T binary system. We discuss how the estimated photometric properties of this object are consistent with the observed J-band brightening of brown dwarfs between late-L and early-T dwarfs, making detailed study of this system an important probe of the L/T transition.

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For preprints contact: kelle@sas.upenn.edu

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L' and M' Photometry of Ultracool Dwarfs

D. A. Golimowski,[1] S. K. Leggett,[2] M. S. Marley,[3] X. Fan,[4] T. R. Geballe,[5] G. R. Knapp,[6] F. J. Vrba,[7] A. A. Henden,[7] C. B. Luginbuhl,[7] H. H. Guetter,[7] J. A. Munn,[7] B. Canzian,[7] W. Zheng,[1] Z. I. Tsvetanov,[8] K. Chiu,[1] K. Glazebrook,[1] E. A. Hoversten,[1] D. P. Schneider,[9,11] and J. Brinkmann[10,11]

[1] Department of Physics and Astronomy, The Johns Hopkins University, 3400 North Charles Street, Baltimore, MD 21218-2686

[2] United Kingdom Infrared Telescope, Joint Astronomy Centre, 660 North A'ohoku Place, Hilo, HI 96720

[3] NASA–Ames Research Center, Mail Stop 245-3, Moffett Field, CA 94035

[4] Steward Observatory, The University of Arizona, Tucson, AZ 85721-0065

[5] Gemini Observatory, 670 North A'ohoku Place, Hilo, HI 96720

[6] Princeton University Observatory, Princeton, NJ 08544
[7] United States Naval Observatory, Flagstaff Station, P.O. Box 1149, Flagstaff, AZ 86002-1149
[8] National Aeronautics and Space Administration, 300 E Street SW, Washington, DC 20546-0001
[9] Department of Astronomy and Astrophysics, Pennsylvania State University, 525 Davey Laboratory, University Park, PA 16802
[10] Apache Point Observatory, 2001 Apache Point Road, P.O. Box 59, Sunspot, NM 88349-0059
[11] Sloan Digital Sky Survey builder.

We have compiled L' (3.4–4.1 μm) and M' (4.6–4.8 μm) photometry of 63 single and binary M, L, and T dwarfs obtained at the United Kingdom Infrared Telescope using the Mauna Kea Observatory (MKO) filter set. This compilation includes new L' measurements of 8 L dwarfs and 13 T dwarfs and new M' measurements of 7 L dwarfs, 5 T dwarfs, and the M1 dwarf Gl 229A. These new data increase by factors of 0.6 and 1.6, respectively, the numbers of ultracool dwarfs ($T_{\rm eff} \lesssim$ 2400 K) for which L' and M' measurements have been reported. We compute $L_{\rm bol}$, BC$_K$, and $T_{\rm eff}$ for 42 dwarfs whose flux-calibrated JHK spectra, L' photometry, and trigonometric parallaxes are available, and we estimate these quantities for 9 other dwarfs whose parallaxes and flux-calibrated spectra have been obtained. BC$_K$ is a well-behaved function of near-infrared spectral type with a dispersion of $\sim$ 0.1 mag for types M6–T5; it is significantly more scattered for types T5–T9. $T_{\rm eff}$ declines steeply and monotonically for types M6–L7 and T4–T9, but is nearly constant at $\sim$ 1450 K for types L7–T4 with assumed ages of $\sim$ 3 Gyr. This constant $T_{\rm eff}$ is evidenced by nearly unchanging values of L'–M' between types L6 and T3. It also supports recent models that attribute the changing near-infrared luminosities and spectral features across the L–T transition to the rapid migration, disruption, and/or thinning of condensate clouds over a narrow range of $T_{\rm eff}$. The L' and M' luminosities of early-T dwarfs do not exhibit the pronounced humps or inflections previously noted in the I through K bands, but insufficient data exist for types L6–T5 to assert that $M_{L'}$ and $M_{M'}$ are strictly monotonic within this range of types. We compare the observed K, L', and M' luminosities of L and T dwarfs in our sample with those predicted by precipitating-cloud and cloud-free models for varying surface gravities and sedimentation efficiencies. The models indicate that the L3–T4.5 dwarfs generally have higher gravities (log g = 5.0–5.5) than the T6–T9 dwarfs (log g = 4.5–5.0). The predicted M' luminosities of late-T dwarfs are 1.5–2.5 times larger than those derived empirically for the late-T dwarfs in our sample. This discrepancy is attributed to absorption at 4.5–4.9 μm by CO, which is not expected under the condition of thermochemical equilibrium assumed in the models. Our photometry and bolometric calculations indicate that the L3 dwarf Kelu-1 and the T0 dwarf SDSS J042348.57–041403.5 are probable binary systems. We compute $\log(L_{\rm bol}/L_\odot) = -5.73 \pm 0.05$ and $T_{\rm eff}$ = 600–750 K for the T9 dwarf 2MASSI J0415195–093506, which supplants Gl 570D as the least luminous and coolest brown dwarf presently known.

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For preprints contact: dag@pha.jhu.edu

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Near-Infrared Photometry and Spectroscopy of L and T Dwarfs: the Effects of Temperature, Clouds, and Gravity

G. R. Knapp[1], S. K. Leggett[2], X. Fan[3], M. S. Marley[4], T. R. Geballe[5], D. A. Golimowski[6], and 23 other authors

[1] Princeton University Observatory, Princeton, NJ 08544
[2] Joint Astronomy Centre, 660 North A'ohoku Place, Hilo, HI 96720
[3] Steward Observatory, The University of Arizona, Tucson, AZ 85721-0065
[4] NASA–Ames Research Center, Mail Stop 245-3, Moffett Field, CA 94035
[5] Gemini Observatory, 670 North A'ohoku Place, Hilo, HI 96720
[6] Department of Physics and Astronomy, The Johns Hopkins University, 3400 North Charles Street, Baltimore, MD 21218-2686

We present JHK photometry and spectroscopy for a sample of newly identified L and T dwarfs from the Sloan Digital Sky Survey (SDSS) and known dwarfs from the SDSS and the Two Micron All Sky Survey (2MASS). Spectral classification has been carried out using four infrared indices; we identify 9 new L8-9.5 dwarfs and 14 new T dwarfs from SDSS, including the latest SDSS dwarf yet found, the T7 SDSS J1758+4633. We classify 2MASS J0415-0935 as T9, the latest and coolest dwarf found to date. We combine these results with previously published data to produce a sample of 59 L dwarfs and 42 T dwarfs. We compare the near-IR colors and absolute magnitudes of dwarfs near

the L-T transition with predictions made by models of the distribution and evolution of photospheric condensates. There is scatter in the spectral indices for L dwarfs, suggesting that these indices are probing different levels of the atmosphere. The near-IR colors of the L dwarfs also scatter, likely due to variations in the altitudes, spatial distributions and thicknesses of the condensate clouds. We identify a group of late L dwarfs that are blue for their spectral type and that have enhanced FeH, H_2O and K I absorption, possibly due to an unusually small amount of condensates. The scatter seen in the H-K color for late T dwarfs can be reproduced by models with a range in surface gravity. The variation is probably due to the effect on the K-band flux of pressure-induced H_2 opacity. The correlation of H-K color with gravity is supported by the strengths of the J-band K I doublet. Gravity is closely related to mass for field T dwarfs and the gravities implied by the H-K colors indicate that the T dwarfs in our sample have masses in the range 15-75 $M_{\rm Jupiter}$, except for SDSS J1110+0116 which possibly has a mass of 10-15 $M_{\rm Jupiter}$.
Accepted by AJ for June 2004 issue *For preprints contact*: s.leggett@jach.hawaii.edu *For preprints via ftp or WWW*: http://arxiv.org/abs/astro-ph/0402451

Dust in the Photospheric Environment II. Effect on the Near Infrared Spectra of L and T Dwarfs

Takashi Tsuji[1], Tadashi Nakajima[2] and Kenshi Yanagisawa[3]

[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
[3] Okayama Astronomical Observatory, National Astronomical Observatory, Kamogata, Okayama, 719-0231 Japan

We report an attempt to interpret the spectra of L and T dwarfs with the use of the Unified Cloudy Model (UCM). For this purpose, we extend the grid of the UCMs to the cases of log $g = 4.5$ and 5.5. The dust column density relative to the gas column density in the observable photosphere is larger at the higher gravities, and molecular line intensity is generally smaller at the higher gravities. The overall spectral energy distributions (SEDs), based on the calibrated spectra observed with the Subaru telescope as detailed in a separate paper (Nakajima, T., Tsuji, T., & Yanagisawa, K., astro-ph/0402186), are $f_J < f_H < f_K$ in middle and late L dwarfs, $f_J < f_H > f_K$ in early T dwarfs (L/T transition objects), and finally $f_J > f_H > f_K$ in middle and late T dwarfs, where f_J, f_H, and f_K are the peak fluxes at J, H, and K bands, respectively, in f_ν unit. This tendency is the opposite to what is expected for the temperature effect, but can be accounted for as the effect of thin dust clouds formed deep in the photosphere together with the effect of the gaseous opacities including H_2 (CIA), H_2O, CH_4, and K I. Although the UCMs are semi-empirical models based on a simple assumption that thin dust clouds form in the region of $T_{\rm cr} \lesssim T \lesssim T_{\rm cond}$ ($T_{\rm cr} \approx 1800\,$K is an only empirical parameter while $T_{\rm cond} \approx 2000\,$K is fixed by the thermodynamical data), the major observations including the overall SEDs as well as the strengths of the major spectral features are consistently accounted for throughout L and T dwarfs. In view of the formidable complexities of the cloud formation, we hope that our UCM can be of some use as a guide for future modelings of the ultracool dwarfs as well as for interpretation of observed data of L and T dwarfs. It is to be noted that the spectra and SEDs based on the UCMs can be evaluated with any spectral synthesis code, only if the dust extinction coefficients are added to the continuous opacity in the layers with $T_{\rm cr} \lesssim T \lesssim T_{\rm cond}$. The numerical details of the UCMs to be used for such applications as well as some results (spectra & SEDs) are available through our web site (http://www.mtk.ioa.s.u-tokyo.ac.jp/~ttsuji/export/ucm).

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

For preprints via ftp or WWW: http://www.mtk.ioa.s.u-tokyo.ac.jp/ ~ttsuji/export/preprints/ or astro-ph/0402192

Spectroscopic Rotation Velocities of L Dwarfs from VLT/UVES and Their Comparison with Periods from Photometric Monitoring

C.A.L. Bailer-Jones[1,2]

[1]Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany
Carnegie Mellon University, Department of Physics, 5000 Forbes Ave., Pittsburgh, PA 15213, USA

The variability and rotation of ultra cool dwarfs (UCDs) provide important information on the atmospheres and evolution of these very low mass stars and brown dwarfs. As part of an ongoing program to investigate this, the projected rotation speeds, $v \sin i$, derived from high resolution VLT/UVES spectroscopy via cross correlation are presented for 16 field UCDs (M9V–L7.5V). This doubles the number of L dwarfs for which $v \sin i$ has been measured.

All targets are found to have $v\,sini$ between 10 and 40 km/s confirming that L dwarfs are rapid rotators. Radial velocities have also been measured to a precision of 1–2 km/s. From the random distribution of the rotation axes, i, and theoretically predicted radii, one-sided confidence intervals are placed on the rotation periods of individual objects. These are compared with published period data obtained from photometric monitoring programs. From this, the period of 31 hrs for the L0.5 dwarf 2M0746+2000 published by Gelino et al. (2002) may be ruled out as the rotation period. The period of 11.2 ± 0.8 hrs for the L1.5 dwarf 2M1145+2317 obtained by Bailer-Jones & Mundt (2001) is consistent with the present $v \sin i$ results so is plausibly the true rotation period. The inclination of the rotation axis is constrained to be i=62°− 90° with an expectation value of 76°. Alternatively the data set a lower limit on the radius of 0.1 $R_{\odot}$, which is within the range of radii predicted by models for brown dwarfs older than 0.5 Gyr. Similarly, the period of 2.7 ± 0.1 hrs detected by the same authors for 2M1334+1940 is also confirmed as the likely rotation period; the inclination is i=27°−44° ($< i >$= 34°). Where no variability or period was detected by the monitoring programs the likely reason is low contrast modulating surface features. However, in three cases variability but no period was detected, even though the likely rotation period range inferred from $v \sin i$ lies within the timescale to which the monitoring was sensitive. This reinforces the 'masking hypothesis' of Bailer-Jones & Mundt (2001), the idea that the evolution of photospheric features on timescales shorter than the rotation period obscure the regular modulation of the light curve. As has been previously discussed, a likely candidate for such features is inhomogeneous dust clouds.

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X-ray Variability of Late-type Stars as a Diagnostic Tool: Age Dependence and Comparison with the Sun

Antonietta Marino

Thesis work conducted at: Dipartimento di Scienze Fisiche e Astronomiche, Sez. di Astronomia, University of Palermo, Italy

Current address: Dipartimento di Scienze Fisiche e Astronomiche, Sez. di Astronomia, Univ. of Palermo, Piazza del Parlamento 1, 90134, Palermo, Italy

E-mail: marino@astropa.unipa.it

Ph.D dissertation directed by: Prof. Giovanni Peres

Ph.D degree awarded: February 2004

In this thesis I study how physical conditions in coronal stellar atmospheres change with stellar age and mass; to this end I perform a thorough analysis of coronae variability. This study was motivated by the strong evolution of X-ray luminosity L_x with stellar age suggesting that the mechanism working in stellar coronae change drastically with age: variability studies are one of the best ways to explore these mechanisms and to infer the physical conditions of the regions where X-ray emission originates. Comparative studies of the variability properties of homogeneous classes (with respect to mass and age) of X-ray sources are ideal to diagnose and to discriminate the mechanisms at the origin of their X-ray emission. To pursue such studies, a large number of observations are required.

In the course of my *laurea* thesis (Marino 1997, Marino et al. 2000, A&A, 353, 177), I developed tested and applied a statistical approach to characterize and compare X-ray variability of homogeneous classes of stellar X-ray sources. During my PhD studies, I further developed and applied this approach to samples of stars with different age and mass.

For the solar-type ($\sim$ 0.9 - 1.4 $M_\odot$) stars in the solar neighborhood, observed with ROSAT satellite, I found that short time scales (< 1 yr) variability is not a common feature as in the less massive stars (dM); we note that nearby stars have a wide spread of ages. My analysis suggests that the X-ray variability of relatively quiet solar-type stars could occur on longer time scales. This finding is consistent with the hypothesis that their X-ray variability may be due to cyclic variations on stars with X-ray luminosity similar to that of the Sun.

The study of the X-ray variability properties of the flux of the whole solar corona, observed as a star, and the comparison of the results with variability properties of nearby solar-like stars shows that X-ray solar variations by a factor

of two are common on time scales of the order of one year, and variations by a factor ten on time scales in the 4 - 7.5 yr range. The comparison with variability properties of nearby stars indicates that a fraction of moderately active stars ($\overline{L}_x < 10^{28}$ erg/s) can have properties similar to the Sun. In order to investigate how the coronal emission properties change with the mass in a sample homogeneous with respect to age and chemical abundance, I analyzed the X-ray variability of solar-type and dM stars in the Pleiades cluster (age $\sim$ 100 Myr) observed with ROSAT-PSPC. I found that on short time scales, the percentage of variable solar-like stars and dM stars is quite similar, suggesting that at Pleiades age the X-ray variability does not depend on mass. The analysis of a few stars observed on medium time scales (15d -1yr) shows that variations on medium or long time scales possibly due to rotational modulation and/or cyclic behavior may be present in solar-like Pleiades stars but not in dM stars. The comparison of my finding for Pleiades stars with the nearby solar-like and dM stars shows that the variations on short time scales for solar-like samples strongly depend on L_x but not on stellar age.

On short time scales the dM Pleiades stars are very similar to dM field stars, suggesting that, for low mass stars, the amplitude of variability does not change significantly with L_x or age. In summary short-term variability of solar-type stars decreases with age (together with luminosity), while long-term variability increases. On the contrary short-term variability of low mass stars is present in all stellar life phases while long-term variations have never been observed.

Finally, I analyzed the XMM-Newton observation of IC 2391, a cluster younger than the Pleiades. It is an ideal laboratory for testing activity-age relations, because it is young enough ($\sim$ 30 Myr) that solar-type stars are just arrived on the zero-age main-sequence. The X-ray spectral analysis of the brightest cluster stars shows that a two thermal components plasma model well fits the spectra of the G-K and M stars, while a 1-T softer model is more appropriate for F stars. Short-term variability is common among IC 2391 members: about the 50% show variability at a confidence level $> 99\%$ as derived with the Kolmogorov-Smirnov test. Furthermore, I found the first unambiguous evidence of X-ray rotational modulation on VXR45, a young fast rotator star of solar mass, member of IC 2391 with a level of X-ray emission $\sim$ 100 times larger than the solar one; this finding suggests that X-ray saturation, observed in very fast rotators may not (or not always) be attributed to a complete filling of the stellar surface with active region but that surface inhomogeneities have to be present.

Thesis-related Publications: A&A, 383, 210; A&A, 406, 629; A&A, 407, L63; IBVS, 5427, 1; A&A, 404, 637

Ph.D. Thesis Abstracts

The Initial Mass Function of Selected Galactic Open Clusters

L. Prisinzano

Thesis work conducted at: Dip. Science Fisiche ed Astronomiche, University of Palermo, Italy

Current address: Piazza del Parlamento, 1 I-90134, Palermo, Italy

E-mail: loredana@astropa.unipa.it

Ph.D dissertation directed by: Prof. S. Serio

Ph.D degree awarded: February 2004

In this thesis I have studied the invariance of the Initial Mass Function (IMF) by means of three open clusters located in the disk of our Galaxy. The clusters have been chosen spanning a large range of age to explore the universality or the variability of the Initial Mass Function as a function of formation epoch in the last billion years.

Although many studies have been carried out in the last years to determine the shape of the Initial Mass Function in different astrophysical environments, the debate about the universality or the variability of the Initial Mass Function remains open. Very recent results seem to suggest that, within very large uncertainties, this function is characterized by a mass scale variable with time. To confirm such fundamental result, based on very sparse results, more and more accurate determinations of the Initial Mass Function are needed. For this reason I have chosen to derive in a self-consistent way the Initial Mass Function of a number of different open clusters in our Galaxy. Stars in a given open cluster are in fact homogeneous in age, distance and chemical composition. In addition they are not too evolved so that stellar evolution and/or dynamical evolution effects can be corrected within a sufficiently wide mass range.

I have studied the following clusters: NGC 6530, a very young open cluster with age estimated in this work in the ($10^{5.5}$–$10^{7.0}$) yr range; the intermediate age open cluster NGC 2422 of age $\sim 10^8$ yr, very similar to the well studied Pleiades cluster, and finally the old open cluster NGC 3960 with age in the (0.9–1.4) 109 yr range.

In all cases, I have analyzed optical multi-band images to obtain magnitudes and colors of the stars and then the Luminosity Function of the selected clusters. Additional X-ray data and photometric near-infrared data available in literature have been used to determine properties of the youngest clusters. Several theoretical stellar evolution models available in literature have been considered to determine the distance and the age of all the clusters and to convert the Luminosity Functions to the Mass Functions.

For NGC 6530, I have derived a distance significantly smaller than the distance derived in the literature. An accurate selection of members belonging to this cluster has been possible using Chandra X-ray data recently obtained by Damiani et al. (2004). A total of 734 optical/X-ray sources have been found and plotted in the color-magnitude diagram. More than 90% of these stars are certain cluster members and identify a well defined pre-main sequence band of the cluster. Individual masses and ages of these stars have been derived from theoretical models. An adequate correction has been applied to the derived Initial Mass Function in order to take into account the incompleteness of X-ray data.

The Luminosity Function of NGC 2422 has been obtained from a sample of candidate cluster members which has been selected photometrically. The fraction of contaminating field stars has been estimated using a comparison field and an iterative procedure which involves both luminosity and spatial distributions. From this analysis, dynamical evolution effects have been found for NGC 2422 and a correction to the mass function has been applied in order to include low-mass stars lying outside our field of view. Within the errors, the Mass Function, thus corrected for dynamical evolution effects, can be considered a good representation of the Initial Mass Function of the cluster, at least in the mass range I have explored. The results indicate that NGC 2422 is very similar to the coeval Pleiades both in terms of the total mass and in terms of the functional form of the Initial Mass Function.

Due to the strong differential reddening affecting the area of NGC 3960, the spatial density distribution of this cluster shows strong gradients which prevent from obtaining a reliable photometric membership of the cluster, mainly for low-mass stars where the Initial Mass Function has been obtained with very large uncertainties. An independent Initial Mass Function, limited to about $0.8\,M_{\odot}$, has been obtained using near-infrared data less affected by interstellar reddening leading to an Initial Mass Function very similar to that inferred by the optical data.

Within the investigated range of age (about 1 billion years), the Initial Mass Functions, that I have derived for the three clusters, have similar shapes. For $M \gtrsim 1\,M_{\odot}$, the two older clusters (NGC 2422 and NGC 3960) have slope consistent within errors, while the very young open cluster NGC 6530 shows a slope slightly flatter, likely because the fraction of massive stars is larger than that of the other two older clusters; this result indicates that this cluster has not yet undergone strong stellar evolution effects, since the oldest stars have age smaller than the typical time scale for their evolution. For all three clusters, the Initial Mass Function shows a peak at a characteristic mass that appears to depend from the age of the clusters. Such evidences of variations of the Initial Mass Function could reflect different physical conditions of the environments where the clusters formed. This conclusion is in agreement with the most recent published observational results, suggesting a time variable Initial Mass Function.

Thesis-related Publications: Prisinzano et al., 2003, A&A, 404; Prisinzano et al., 2004, A&A, in press

Upcoming Meeting

Announcement of Special Session at the May/June 2004 AAS Meeting

The UV/Optical Universe at Ultra-High Angular Resolution: Science Drivers, Current Capabilities and Future Prospects

31 May 2004
Denver, Colorado

The next major observational advances in UV/Optical astronomy across a broad variety of science topics will require quantum leaps in sensitivity (total collecting area) or in angular resolution (collector size/baselines). The former are being pursued with concepts such as the James Webb Space Telescope (JWST), the Next Hubble Space Telescope (NHST), and the Terrestrial Planet Finder (TPF) – Coronagraphic Option, which use large filled or segmented apertures. The latter will be pursued with large sparse aperture or interferometric designs such as the Space Interferometry Mission (SIM), TPF - Interferometer Option, Stellar Imager (SI), Micro-Arcsecond X-ray Imaging Mission (MAXIM) and Planet Imager (PI).

The science goals and needs for dramatically increased sensitivity have already been addressed in several workshops and sessions, including the Chicago "Hubble Science Legacy Workshop". This AAS Special Session will therefore focus on the goals and needs for ultra-high (sub-milliarcsec) spatial (angular) resolution, with the intent of initiating and invigorating a community discussion on the topic.

The session, which will cover a broad range of science topics, will consist of oral invited papers with discussions, plus an associated contributed poster session on the same day. **Posters on science drivers and various mission concepts that address those drivers are therefore solicited from the community.** The deadline for receipt of abstracts is March 24, 2004.

Abstract submission instructions can be found at: http://www.aas.org/meetings/aas204/prelim/

The provisional Agenda for the Session is as follows:

Part 1: Science Drivers (40 minutes, including questions)
Stellar Activity & Impact on life in the universe
C. Schrijver (LMATC)

The Universe at High Angular Resolution
M. Karovska (SAO)

Part 2: Achieving the Science Goals (40 min)

Current Capabilities for High Angular Resolution Imaging in the UV/optical
(Doppler Imaging and Tomography, ground-based interferometry, Reverberation Mapping, Asteroseismology)
F. Walter (SUNY)

Future Prospects for Very High Angular Resolution Imaging in the UV/Optical
(Space-based Large Monolithic/Segmented Telescopes and Interferometers/Sparse Aperture Telescopes)
R. Allen (STScI)

Part 3: Additional discussion (all speakers) (10m)

Part 4: Associated contributed poster session (all day)

Science Organizing Committee:
K. Carpenter (Chair), Kenneth.G.Carpenter@nasa.gov,
T.J. Armstrong, A. Brown, J. Linsky, L. Mazzuca, R. Robinson, R. Stencel

Job Opening

Postdoctoral Fellow
Computational Astrophysics
School of Physics
Univ. of Sydney (Aust.)

Applications are invited for a Postdoctoral Fellow to work with Dr. Geraint F. Lewis, Dr. Tim Bedding and Dr. Mike Wheatland on the development of new inverse modeling techniques in gravitational lensing, stellar oscillations and/or solar flares. These studies will form part of the Australian initiative for the inclusion of theoretical astrophysics within the Virtual Observatory.

A PhD or equivalent in Astronomy is essential and applicants must show a proven ability for excellence in research. Applicants must also show evidence of the potential for future development and of the ability to work co-operatively with others. Experience in aspects of computational astrophysics is essential, and experience in high-level computer programming (including parallel processing), graphical representation of data/models and an understanding of observational procedures are desirable.

The position is full-time fixed term 12 months, subject to the completion of a satisfactory probation period for new appointees. Further offers of employment for up to two years are probable, subject to funding and need.

For further information contact:

Dr. Geraint F. Lewis Tel : +61 (0)2 9351 5184, e-mail: gfl@physics.usyd.edu.au

Dr. Tim Bedding Tel : +61 (0)2 9351 2680, e-mail: bedding@physics.usyd.edu.au

Dr. Mike Wheatland Tel : +61 (0)2 9351 5965, e-mail: wheat@physics.usyd.edu.au.

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Instructions for applicants: http://www.physics.usyd.edu.au/jobs.html

Closing Date: 30 April 2004

Job Opening

Postdoctoral Research Assistant (RA1A)
Theoretical Astrophysics Group
Univ. of Oxford (U.K.)

Salary: 18,265 – 27339 pounds pa.

Applications are invited for a PPARC funded postdoctoral research position in the Theoretical Astrophysics Group in the Rudolf Peierls Institute for Theoretical Physics. The project is concerned with establishing and understanding the systematic behaviour of the outer atmospheres of cool main-sequence stars (chromospheres to coronae). Use will be made of ultraviolet and X-ray spectra obtained from satellites, including the Hubble Space Telescope, Chandra and XMM-Newton. Candidates are expected to have been awarded a doctorate in a relevant area of astrophysics, which could include expertise in modelling from emission line spectra and radiative transfer calculations.

The salary will be age-related and the maximum duration of the post will be three years. The post will be available from 1 May 2004. Applications should include a Curriculum Vitae, a brief report on research to date and the names and addresses of two referees, and should be sent to Mrs G. Dancey, The Rudolf Peierls Institute for Theoretical Physics, 1 Keble Road, Oxford, OX1 3NP, UK by the closing date of 31 March 2004, quoting reference **DR04/002**. Referees should be asked to write directly to Mrs Dancey by the same date.

For further information contact Prof. C. Jordan (cj@thphys.ox.ac.uk).

Job Opening

Predoctoral Fellowships (2004)
Smithsonian Astrophysical Observatory
Cambridge, MA (USA)

The Smithsonian Astrophysical Observatory announces the availability of predoctoral fellowships beginning in July 2004, designed to allow students from other institutions throughout the world to do part or all of their thesis research at SAO. A wide variety of research projects may be proposed, with about 200 SAO scientific staff available as research advisors. Facilities at SAO include the MMT, Magellan, and other optical and infrared telescopes; radio telescopes, including the Submillimeter Array being constructed on Mauna Kea, Hawaii; a large network of workstations; a number of specialized laboratories; an outstanding library system; and access to data from a wide range of space missions.

Further information on the program can be found at

http://cfa-www.harvard.edu/predoc/

Applicants can contact directly Smithsonian scientists in their areas of interest, or the Program Scientist at predoc@cfa.harvard.edu, to discuss possible research topics.

Applicants must be ready to begin dissertation research at the time of the award. Fellowships are awarded for one year at a time with possible renewal for up to three years, contingent upon funding. Stipends will be $24,600 for the coming year. Applications are due by 15 April 2004. Application forms can be found at the web address above, and should be completed and mailed to SAO. Electronic or fax submissions will not be accepted.

The CfA is an Equal Opportunity/Affirmative Action Employer where all qualified applicants receive consideration for employment without regard to race, creed, sex or national origin.

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 .`

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