COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

The Hydrodynamical Structure of Circumstellar Envelopes Around Low Mass-loss Rate, Low Outflow Velocity AGB Stars

J.M. Winters[1], T. Le Bertre[2], L.-Å. Nyman[3], A. Omont[4] and K.S. Jeong[2]

[1] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
[2] LERMA, Observatoire de Paris, 61 av. de l'Observatoire, F-75014 Paris, France
[3] Swedish-ESO Submillimetre Telescope, European Southern Observatory, Casilla 19001, Santiago 19, Chile
[4] Institut d'Astrophysique de Paris, CNRS, 98bis Boulevard Arago, Paris F75014, France

Recent hydrodynamical models (Winters et al. 2000b) allow the existence of pulsating, large velocity amplitude Asymptotic Giant Branch (AGB) stars with tenuous dusty circumstellar shells, which produce low mass-loss rates and simultaneously low wind velocities. The Semi-regular long-period variable L^2 Pup shows a broad SiO maser feature at 86 GHz (v=1, J=2-1), indicating an outward velocity of the material close to the stellar photosphere of at least $10\,\mathrm{km\,s^{-1}}$, and narrow CO (J=2-1) and (1-0) line profiles indicating an outflow velocity of the material in the circumstellar shell of only about $3\,\mathrm{km\,s^{-1}}$. This can be explained in terms of our hydrodynamical models which provide large velocities in the shocked stellar atmosphere and low velocities of the circumstellar outflow.

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For preprints contact: jwinters@mpifr-bonn.mpg.de

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http://www.mpifr-bonn.mpg.de/div/ ir-interferometry/papers/Winters_etal_AuA_LLPup_2002.html

Chromospherically Active Stars. XXI. The Giant, Single-lined Binaries HD 89546 and HD 113816

Francis C. Fekel[1], **Gregory W. Henry**[1], **Joel A. Eaton**[1], **Julius Sperauskas**[2] **and Douglas S. Hall**[3]

[1] Center of Excellence in Information Systems, Tennessee State University, 330 10th Avenue North, Nashville, Tennessee 37203
[2] Vilnius University Observatory, Ciurlionio 29, Vilnius 2009, Lithuania
[3] Dyer Observatory, Vanderbilt University, Nashville, Tennessee 37235

We have obtained spectroscopy and photometry of the chromospherically active, single-lined spectroscopic binaries HD 89546 and HD 113816. HD 89546 has a circular orbit with a period of 21.3596 days. Its primary has a spectral type of G9 III and is somewhat metal poor with [Fe/H] ~ -0.5. HD 113816 has an orbit with a period of 23.6546 and a low eccentricity of 0.022. Its mass function is extremely small, 0.0007 solar masses, consistent with a very low inclination. The primary is a slightly metal poor K2 III. A decade or more of photometric monitoring with an automatic telescope demonstrates that both systems display brightness variations due to rotational modulation of the visibility of photospheric star spots, as well as light-curve changes resulting from the redistribution of star spots by differential rotation and long-term changes in the filling factor of the spots. We determined rotation periods for each season when the observations were numerous enough. Our mean rotation periods of 21.3 and 24.1 days for HD 89546 and HD 113816, respectively, confirm that the giants in each system are synchronously rotating. The orbital elements and properties of the giant components of these two systems, including levels of surface magnetic activity, are quite similar. However, the two rotational inclinations are rather different, 57 deg for HD 89546 and 13 deg for HD 113816. Thus, the latter giant is seen nearly pole on. We analyzed the light curves for similarities and differences that result from viewing these two systems from quite different inclinations.

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For preprints contact: fekel@evans.tsuniv.edu

Wavelet Analysis of Stellar Differential Rotation II. The Sun in Ultraviolet

Alexander Hempelmann[1]

[1] Universität Hamburg, Hamburger Sternwarte, Gojenbergsweg 112, D-21029 Hamburg, Germany

Among the several methods to study differential rotation on stellar surfaces the observation of a stellar butterfly diagram, i.e. monitoring the rotation period over a complete activity cycle, is the only method which can be applied to stars rotating as slow as the Sun. However, the method requires active belts on the stellar surface which are moving continously in stellar latitude during a cycle. In addition, an appropriate activity tracer showing rotational modulation is needed. Tracers which even work for slowly rotating, i.e. weakly active, stars are the emission cores of certain spectral lines. However, the question is whether surface differential rotation can be determined from this kind of observations and furthermore, which method of analysis is best suited to yield a correct result. We investigate observations of the Sun as a star, i.e. disk-integrated measurements, to answer these questions. In a paper I it was demonstrated that time-frequency analysis using the wavelet transform is possibly a suitable method for monitoring the stellar butterfly diagram. It was also shown that – in comparison with Fourier analysis – wavelet analysis of disk-integrated solar Ca II K line core emission measures yield a much more realistic pattern of the solar differential rotation. In this paper II disk-integrated solar measures in Mg II h+k and Lyman α taken from public UARLS Solstice data are analysed using the same methods as in paperI. In these data solar rotational modulation is much more pronounced than in earlier Ca II K time-series. Wavelet analysis yields the following results: from the beginning of the time-series in 1991 until the end of solar cycle 22 the period of rotational modulation remains stable at 26.9–27.0 days. It is followed by a jump to 27.6 days when the new cycle 23 starts. Then the period rapidly decreases to 26.9 days again until the end of the time-series in 1999. However, the analysis is hampered by frequent period splitting into two modes. It can be shown that this kind of splitting results from phase jumps in the time-series coming from active region growth and decay at 180° shifted solar longitudes.

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Multiwavelength Optical Observations of Chromospherically Active Binary Systems. IV. The X-ray/EUV Selected Binary BK Psc (2RE J0039+103)

M.C. Gálvez[1], D. Montes[1], M.J. Fernández-Figueroa[1], J. López-Santiago[1], E. De Castro[1], M. Cornide[1]

[1]Departamento de Astrofísica, Facultad de Físicas, Universidad Complutense de Madrid, E-28040 Madrid, Spain

We present high resolution echelle spectra taken during four observing runs from 1999 to 2001 of the recently X-ray/EUV selected chromospherically active binary BK Psc (2RE J0039+103). Our observations confirm the single-lined spectroscopic binary (SB1) nature of this system and allow us to obtain, for the first time, the orbital solution of the system as in the case of a SB2 system. We have determined precise radial velocities of both components: for the primary by using the cross correlation technique, and for the secondary by using its chromospheric emission lines. We have obtained a circular orbit with an orbital period of 2.1663 days, very close to its photometric period of 2.24 days (indicating synchronous rotation). The spectral type (K5V) we determined for our spectra and the mass ratio (1.8) and minimum masses ($M sin^3 i$) resulting from the orbital solution are compatible with the observed K5V primary and an unseen M3V secondary. Using this spectral classification, the projected rotational velocity ($v \sin i$, of 17.1 km s^{-1}) obtained from the width of the cross-correlation function and the data provided by HIPPARCOS, we have derived other fundamental stellar parameters. The kinematics and the non- detection of the Li I line indicate that it is an old star. The analysis of the optical chromospheric activity indicators from the Ca II H & K to Ca II IRT lines, by using the spectral subtraction technique, indicates that both components of the binary system show high levels of chromospheric activity. Hα emission above the continuum from both components is a persistent feature of this system during the period 1999 to 2001 of our observations as well as in previous observations. The Hα and Hβ emission seems to arise from prominence-like material, and the Ca II IRT emission from plage-like regions.

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Opacity in the Upper Atmosphere of AU Mic

D.S. Bloomfield[1], M. Mathioudakis[1], D.J. Christian[2], F.P. Keenan[1] and J.L. Linsky[3]

[1] Department of Pure & Applied Physics, Queen's University of Belfast, Belfast, BT7 1NN, Northern Ireland, U.K.
[2] Department of Physics & Astronomy, Johns Hopkins University, 3400 North Charles St., Baltimore, MD 21218, USA
[3] JILA, University of Colorado, Boulder, CO 80309, USA; and National Institute of Standards and Technology, USA

In this paper we investigate the validity of the optically thin assumption in the transition region of the late–type star AU Mic. We use Far–Ultraviolet Spectroscopic Explorer (FUSE) observations of the C III multiplet and O VI resonance lines, hence yielding information at two different levels within the atmosphere. Significant deviations from the optically thin fluxes are found for C III in both quiescent and flare spectra, where only 60% of the flux is actually observed. This could explain the apparent deviation of C III observed in emission measure distributions. We utilize escape probabilities for both homogeneous and inhomogeneous geometries and calculate optical depths as high as 10 for the C III 1175.71 Å component of the multiplet. Using a lower limit to the electron density (10^{11} cm^{-3}) we derive an effective thickness of < 100 km for the scattering layer. The emission originates from very small and compact regions, consistent with a filling factor of 10^{-5} derived for the flare plasma.

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For preprints contact: s.bloomfield@qub.ac.uk

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A Distant Stellar Companion in the Upsilon Andromedae System

Patrick J. Lowrance[1,2], J. Davy Kirkpatrick[2] and Charles A. Beichman[1]

[1] Jet Propulsion Lab, 4800 Oak Grove Dr, Pasadena, CA 91109
[2] Infrared Processing and Analysis Center, California Institute of Technology, MS 100-22, Pasadena, CA 91125

Upsilon Andromedae is an F8V star known to have an extrasolar system of at least 3 planets in orbit around it. Here we report the discovery of a low-mass stellar companion to this system. The companion shares common proper motion, lies at a projected separation of 750 AU, and has a spectral type of M4.5V. The effect of this star on the radial velocity

of the brighter primary is negligible, but this system provides an interesting testbed for stellar planetary formation theory and understanding dynamical stability since it is the first multiple planetary system known in a multiple stellar system.

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For preprints contact: lowrance@ipac.caltech.edu

An Interferometric-Spectroscopic Orbit for the Binary HD 195987: Testing Models of Stellar Evolution for Metal-poor Stars

Guillermo Torres[1], Andrew F. Boden[2,3], David W. Latham[1], Margaret Pan[1,4] and Robert P. Stefanik[1]

[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge MA 02138 USA

[2] Interferometry Science Center, California Institute of Technology, 770 South Wilson Ave., Pasadena CA 91125 USA

[3] Department of Physics and Astronomy, Georgia State University, 29 Peachtree Center Ave., Science Annex, Suite 400, Atlanta GA 30303 USA

[4] Present address: Palomar Observatory, California Institute of Technology, 770 South Wilson Ave., Pasadena CA 91125 USA

We report spectroscopic and interferometric observations of the moderately metal-poor double-lined binary system HD 195987, with an orbital period of 57.3 days. By combining our radial-velocity and visibility measurements we determine the orbital elements and derive absolute masses for the components of $M_A = 0.844 \pm 0.018$ M$_\odot$ and $M_B = 0.6650 \pm 0.0079$ M$_\odot$, with relative errors of 2% and 1%, respectively. We also determine the orbital parallax, $\pi_{\rm orb} = 46.08 \pm 0.27$ mas, corresponding to a distance of 21.70 ± 0.13 pc. The parallax and the measured brightness difference between the stars in V, H, and K yield the component absolute magnitudes in those bands. We also estimate the effective temperatures of the stars as $T_{\rm eff}^A = 5200 \pm 100$ K and $T_{\rm eff}^B = 4200 \pm 200$ K. Together with detailed chemical abundance analyses from the literature giving [Fe/H]≈ -0.5 (corrected for binarity) and [α/Fe]$= +0.36$, we use these physical properties to test current models of stellar evolution for metal-poor stars. Among the four that we considered, we find that no single model fits all observed properties at the measured composition, although we identify the assumptions in each one that account for the discrepancy and we conclude that a model with the proper combination of assumptions should be able to reproduce all the radiative properties. The indications from the isochrone fits and the pattern of enhancement of the metals in HD 195987 are consistent with this being a thick disk object, with an age of 10–12 Gyr.

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For preprints contact: gtorres@cfa.harvard.edu

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Study of FK Comae Berenices IV. Active Longitudes and the “Flip-Flop” Phenomenon

H. Korhonen[1], S.V. Berdyugina[1] and I. Tuominen[1]

[1] Astronomy Division, P.O. Box 3000, FIN-90014 University of Oulu, Finland

Doppler imaging techniques have earlier been used to study the starspots and their evolution over a four year period in a single, late-type star FK Com. In the present work we publish new photometric observations of FK Com for the year 2001 and analyse them together with the previously published photometry obtained since 1966. These observations enable us to study the spot configuration on the stellar surface over much longer time period than the Doppler imaging alone permits, and so to look for possible activity cycles. The longitudinal spot configuration is recovered from the spot filling factor maps obtained with light curve inversion method. From the maps it is clear that the shape of the light curve is usually caused by one active region, which is often extended, and only occasionally by two regions. The spots tend to occur at two active longitudes which are 180° apart. These active longitudes are periodically active, i.e. the dominant part of the spot activity abruptly changes the longitude after about 3 years, indicating the “flip-flop” event. The full activity cycle is estimated to be 6.4 years. There is also clear evidence for migration of the active longitudes with at least three different rates. These rates correspond to the rotational periods of 2.40038 ± 0.00009 days (for the years 1979–1993), 2.4030 ± 0.0003 (1994–1997) and 2.3960 ± 0.0004 (1997–2001). These periods are confirmed by using a more traditional time series analysis. The different migration rates of the active longitudes can be explained by weak solar-type differential rotation

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For preprints contact: heidi.korhonen@oulu.fi

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Detection of the Neupert Effect in the Corona of an RS CVn Binary System by *XMM-Newton* and the VLA

Manuel Güdel[1], Marc Audard[1], Kester W. Smith[1,2], Ehud Behar[3], Anthony J. Beasley[4] and Rolf Mewe[5]

[1] Paul Scherrer Institut, Würenlingen and Villigen, CH-5232 Villigen PSI, Switzerland
[2] Institut für Astronomie, ETH Zentrum, CH-8092 Zürich, Switzerland
[3] Columbia Astrophysics Laboratory, Columbia University, 550 West 120th Street, New York, NY 10027, USA
[4] Owens Valley Radio Observatory, California Institute of Technology, Big Pine, CA 93513, USA
[5] SRON National Institute for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands

The RS CVn-type binary σ Geminorum was observed during a large, long-duration flare simultaneously with *XMM-Newton* and the VLA. The light curves show a characteristic time dependence that is compatible with the Neupert effect observed in solar flares: The time derivative of the X-ray light curve resembles the radio light curve. This observation can be interpreted in terms of a standard flare scenario in which accelerated coronal electrons reach the chromosphere where they heat the cool plasma and induce chromospheric evaporation. Such a scenario can only hold if the amount of energy in the fast electrons is sufficient to explain the X-ray radiative losses. We present a plausibility analysis that supports the chromospheric evaporation model.

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Asymptoptic Dynamos in Late-type Stars

L.釘Paternò[1], G. Belvedere[1], K. M. Kuzanyan[2,3], A. F. Lanza[4]

[1] Department of Physics and Astronomy, University of Catania, Via S. Sofia, 78 - 95123 Catania, Italy
[2] IZMIRAN, Solar-Terrestrial Department, 142092 Moscow Region, Russia
[3] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China
[4] Catania Astrophysical Observatory of the National Institute of Astrophysics, Via Santa Sofia, 78 - 95123 Catania, Italy

The behaviour of a simple thin-shell α-Ω dynamo model is considered in the asymptotic regime, characterized by dynamo numbers much larger than the critical ones, in order to derive scaling relationships connecting the properties of dynamo waves with global stellar parameters. The proposed approach is applied to stellar models of sub-giant and giant stars from K0IV to K1III spectral types in H-R diagram, to predict some characteristics of activity cycles in very active stars. We found that the strength of the dynamo action in such stars is higher than in the Sun. Therefore, larger magnetic field energy and larger spot filling factors are expected, in agreement with observations. The periods of stellar cycles are also estimated and compared with observations. The characteristic times of migration of the star-spot belts relative to the cycle period, namely the Hale number, together with the ratio of toroidal to poloidal dynamo magnetic fields are estimated. From our simplified analysis we can only derive general trends, but can not perform a direct comparison with the observed properties of particular active stars. These general trends indicate that the cycle periods have a large spread for stars with low rotation rates ($\sim 1-5$ times the solar one), while they tend to be saturated for stars with high rotation rates ($\sim 5-15$ times solar), for which the periods range from 10 to 20 years. For such stars, Hale numbers range from 1.5 to about 4 (Hale number for the Sun is about 1.1), denoting the possible existence of cycles with different periodicities simultaneously present, the ratio of toroidal to poloidal dynamo fields tends to become smaller for increasing rotation rates, indicating a transition from the α-Ω to the α^2-Ω type of dynamo. Moreover, the magnetic field filling factors tend to become larger for faster rotation rates, though the effect of the convection zone depth should not be neglected. Our results show a reasonable agreement with available observations of a sample of active stars we have considered.

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For preprints contact: nlanza@ct.astro.it

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Asteroseismic Tests for Models of Magnetically Active Close Binaries with Orbital Period Modulation

A. F. Lanza[1], **M. Rodonò**[2]

[1] INAF – Osservatorio Astrofisico di Catania

[2] Dipartimento di Fisica e Astronomia dell'Università degli Studi di Catania, Via S. Sofia, 78 – 95123 Catania, Italy

Magnetic activity and orbital period modulation in close binaries are considered in order to identify possible asteroseismic tests for models that have been proposed to understand their relationship. These models are based on the variation of the gravitational quadrupole moment of the active star, as a consequence of the modification of its internal rotation and magnetic field along its activity cycle (Applegate 1992; Lanza et al. 1998a). An analysis based on the solar analogy shows that surface magnetic activity may produce shifts, splitting and broadening of the p-mode peaks in the oscillation spectrum of a star. Such effects make the direct detection of the internal structural changes predicted by the models very difficult. However, a time variation of the internal rotation can be detectable because the p-mode rotational splittings are proportional to the azimuthal quantum number m, whereas structural and surface effects controlled by the magnetic fields are $|m|$ dependent. Therefore, we propose a method that correlates the variation of the a_1 splitting coefficients, that sample the internal rotation, with the orbital period variation in order to test the predictions of the models. The RS CVn short-period systems, such as V 471 Tau, RT And or CG Cyg, are the most suitable objects for such a test because surface magnetic effects are likely to be less prominent than in classical or long-period RS CVn binaries.

A&A in press

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Gravitational Quadrupole-moment Variations in Active Binaries

A. F. Lanza[1], **M. Rodonò**[2]

[1] INAF – Osservatorio Astrofisico di Catania

[2] Dipartimento di Fisica e Astronomia dell'Università degli Studi di Catania, Via S. Sofia, 78 – 95123 Catania, Italy

The principal characteristics of the observed orbital period variation in magnetically active close binaries are briefly reviewed and the theoretical models proposed to interpret them are presented. In particular, we focus on the models proposed by Applegate (1992) and Lanza, Rodonò & Rosner (1998a) to explain the short-term modulation of the orbital period, as a consequence of the changes of the gravitational quadrupole moment of the active component driven by a cyclic hydromagnetic dynamo. Recent observational results support our interpretation and the constraints on the intensity of the internal magnetic fields that are required by the proposed mechanism, are discussed. A novel, stringent test of our model based on future asteroseismic space observations of oscillation mode splitting is also briefly presented.

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For preprints contact: nlanza@ct.astro.it

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Monitoring of Spotted RS CVn and BY Dra Type Stars. I. Simultaneous Optical and Infrared Photometry

P.J. Amado[1], M. Zboril[2], C.J. Butler[3] and P.B. Byrne[3*]

[1] Instituto de Astrofísica de Andalucía-CSIC. Apdo. 3004, 18080, Granada, Spain

[2] Astronomical Institute of the Slovak Academy od Science, 059 60 Tatranská Lomnica, The Slovak Republic

[3] Armagh Observatory, College Hill, Armagh BT61 9DG, N. Ireland

[*] Deceased

UBV(RI)$_c$ JHK photometry of 6 active stars, collected at the South African Astronomical Observatory in 1996 and 1997, is presented. The light and colour curves, which are compared with those observed at previous epochs, show significant variation in their wave-like modulation and in their maximum brightness.

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For preprints contact: pja@iaa.es

Solar Abstracts

Does the Sun have a Full-Time COmosphere?

T. R. Ayres[1]

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

Off-limb emissions of solar 4.7 μm rovibrational bands of carbon monoxide, recorded under excellent observing conditions with the Infrared Imaging Spectrograph (IRIS) at the McMath-Pierce telescope, are compared with theoretical translimb CO simulations based on time slices from the Carlsson & Stein dynamical model of chromospheric "K grains." In the Carlsson-Stein view, the solar outer atmosphere—in non-magnetic internetwork regions—is a spatially and temporally intermittent wave-driven phenomenon, yielding an average thermal profile in the classical low chromosphere which is cool, not hot. Recent papers by Kalkofen and collaborators have criticized the dynamical model in favor of traditional "layered" stratifications in which temperatures vary smoothly with altitude and are warm throughout the chromosphere. The present work sharpens the controversy by reiterating that traditional models with warm thermal profiles in the altitude range 500–1000 km fail two key "infrared CO" tests. The same tests reveal that the Carlsson-Stein dynamical model—which Kalkofen et al. argue is too cool in the low chromosphere—is *not cold enough.* Equally important, there need not be any contradiction between the existence of cool gas above the classical temperature minimum, and observations of ubiquitous ultraviolet emission from the solar outer atmosphere, a central criticism by Kalkofen and collaborators of a full-time cold "COmosphere."

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Low-Mass and Substellar Abstracts

Discovery of Three L-Dwarfs in the Southern Sky **Nicolas Lodieu[1], Ralf-Dieter Scholz[1] and Mark J. McCaughrean[1]**

[1] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14 482 Potsdam, Germany

We report the discovery of three L-dwarfs in the solar vicinity within 30 parsecs. These objects were originally found as proper motion objects from a combination of R and I photographic plates measured as part of the SuperCOSMOS Sky Surveys. We subsequently identified these objects as bona fide brown dwarf candidates on the basis of their R-I colour, as first criterion, and subsequently their J-K colours when the infrared data were available from the 2MASS

database. Spectroscopic observations in the optical with the ESO 3.6m/EFOSC2 and in the near-infrared with the NTT/SOFI led to the classification of their spectral types as early L dwarfs.

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For preprints contact: nlodieu@aip.de *For preprints via ftp or WWW*: astro-ph/0205098

The Y-Band at 1.035 μm: Photometric Calibration and the Dwarf Stellar / Sub-stellar Color Sequence

Lynne A. Hillenbrand[1], Jonathan B. Foster[1], S.E. Persson[2], K. Matthews[3]

[1] California Institute of Technology; Dept. of Astronomy; MS 105-24; Pasadena, CA 91125
[2] Observatories of the Carnegie Institution of Washington; 813 Santa Barbara Street; Pasadena, CA 91101
[3] California Institute of Technology; Palomar Observatory; MS 320-47; Pasadena, CA 91125

We define and characterize a photometric bandpass (called "Y") that is centered at 1.035 μm, in between the traditionally classified "optical" and "infrared" spectral regimes. We present Y magnitudes and Y-H and Y-K colors for a sample consisting mostly of photometric and spectral standards, spanning the spectral type range sdO to T5V. Deep molecular absorption features in the near-infrared spectra of extremely cool objects are such that the Y-H and Y-K colors grow rapidly with advancing spectral type especially from late M through mid L, substantially more rapidly than J-H or H-K which span a smaller total dynamic range. Consistent with other near-infrared colors, however, Y-H and Y-K colors turn blueward in the L6-L8 temperature range with later T-type objects having colors similar to those of warmer M and L stars. Use of the Y-band filter is nonetheless promising for easy identification of low-mass stars and brown dwarfs, especially at young ages. In particular, the Y-J color remains constant at 1.0±0.15 mag from early-L through late-T dwarfs. The slope of the interstellar reddening vector within the Y filter is $A_Y = 0.38 \times A_V$. Reddening moves stars nearly along the YHK dwarf color sequence making it more difficult to distinguish unambiguously very low mass candidate brown dwarf objects from higher mass stars seen, e.g. through the galactic plane or towards star-forming regions. Other diagrams involving the Y-band may be somewhat more discriminating.

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Dust Clouds or Magnetic Spots? Exploring the Atmospheres of L dwarfs with Time-resolved Spectrophotometry

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

[1]Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany

I present the results of a program to spectrophotometrically monitor the L1.5 dwarf 2MASSW J1145572+231730 to identify the cause of photospheric variability in ultra cool dwarfs. Plausible candidates are magnetically-induced star spots and inhomogeneous photospheric dust clouds. Based on the atmospheric models and synthetic spectra of Allard et al. (2001), the expected signatures of these phenomena in the 0.5–2.5 μm wavelength region are presented and discussed. Near infrared spectra of 2M1145 were obtained along with a nearby reference star observed simultaneously in the spectrograph slit. No convincing variability over a 54 hour interval is found in any one of several colour indices designed to be most sensitive to dust- and spot-related variability. Nonetheless, a significant *correlation* between the variability of two colour indices is found. This is slightly more consistent with the dust-related variability model than the cool spot one considered. Based on the theoretically predicted signatures and the median errors in the colour indices (0.03-0.05 magnitudes), upper limits are placed on the coverage of possible spots and clouds. Assuming the L dwarf to be best modelled by a dusty atmosphere at 1900 K, coherent clear clouds are limited to a coverage of 10–15% of the projected surface area and 200 K cooler spots to a 20% coverage. A larger coverage of many small features varying incoherently cannot be be ruled out this method. A lower effective temperature restricts coherent clear clouds to be much smaller; a higher temperature allows both clouds and spots to be larger. These upper limits are consistent with the two separate variability *detections* in the I-band reported by Bailer-Jones & Mundt (2001).

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Multi-Wavelength Observations of Flares and Variability in the Coronae of Active Binary Systems

Rachel A. Osten

Thesis work conducted at: University of Colorado, Boulder USA

Current address: CASA, UCB 389, Univ. of Colorado, Boulder, CO 80309-0389 USA

E-mail: raosten@casa.colorado.edu

Ph.D dissertation directed by: Thomas R. Ayres and Alexander Brown

Ph.D degree awarded: May 2002

I investigate the multi-wavelength properties of stellar flares on active binary systems, concentrat ing on X-ray/extreme ultraviolet (EUV) and radio observations of thermal and nonthermal coronal plasmas. I examine the frequency of flaring events in active binary systems in the EUV bandpass, and find that they undergo large scale flares $\approx 40\%$ of the time, with a dynamic range between quiescent and flare luminosities less than a factor of ten. Long duration flares lasting days appear to be common, and there is evidence for variability even when no large flares are obvious. Some coronal flares exhibit long rise times, comparable to the decay timescale. Other flare phenomena observed include a slow brightening before the impulsive phase of the flare, and two different timescales during the flare decay.

Dramatic abundance and temperature changes are present in coronae during some flares, with enhancements up to a factor of four between quiescent and flaring iron abundances, and evidence for plasma temperatures > 50 MK during flares. The distribution of thermal coronal plasma with temperature is bimodal with a peak around 6–8 10^6K and another at 20–30 10^6 K. The hotter temperature peak moves to higher temperatures during flares.

Highly polarized, highly time-variable emission at 20 cm is due to a coherent emission mechanism, most likely emission at the plasma frequency or second harmonic, and is a common feature of low frequency radio emission on active binary systems. Gyrosynchrotron flares at higher radio frequencies show very little net polarization, in contrast with coherent phenomena which reveal large degrees of polarization.

Radio and X-ray flares do show correlations; some patterns are consistent with solar flare multi-wavelength patterns while others are not. This presents a complex view of flaring. Flares demonstrate an increased contrast over the quiescent level at higher X-ray energies, and the flare evolution proceeds at a faster rate at higher energies. The question to what extent the solar-stellar connection holds with regards to the physics of flares is complicated: there is evidence for and against a connection.

Thesis-related Publications: ApJ, 515, 746; ApJ, 544, 953; ApJS 138, 99

Coronal and Transition Region Observations of the Sun and Cool Stars

David R. Williams

Thesis work conducted at: The Queen's University of Belfast, Belfast, BT7 1NN, Northern Ireland, UK.

Current address: Mullard Space Science Laboratory, University College London, Holmbury St Mary, Dorking, Surrey, RH5 6NT, UK.

E-mail: drw@mssl.ucl.ac.uk

Ph.D dissertation directed by: Dr Mihalis Mathioudakis, Prof. Francis P. Keenan, Prof. Kenneth J.H. Phillips

Ph.D degree awarded: March 2002

This thesis presents observations of dynamic events in the outer atmosphere of the Sun and other cool stars. The effect of opacity on ratios of strong transition region lines is investigated for the flare dMe star YZ CMi, and the RS CVn binary Capella. Opacity is shown to be both an important effect in these stars' atmospheres and an important diagnostic tool for scale distances. Also presented are observations of a class C5.2 flare on the Sun. The flare's energy release is shown to be largely in the form of mass motions of ejected plasma, and is compared to the energy of particles injected into the lower atmosphere.

The largest part of the thesis deals with the investigation of short-period oscillations in the solar corona. Theoretical considerations suggest that short-period MHD waves may make a significant contribution to coronal heating. I have identified a strong 6-second oscillation in an active region coronal loop. Near-simultaneous *SoHO* observations are used to determine the physical parameters of the loop. The oscillation is associated with a fast-mode wave travelling with a velocity of 2000 km s^{-1}. Although the wave travels a distance greater than $\lambda/4\pi$ and therefore meets a necessary criterion for slow dissipation, the dissipation length is well in excess of the loop length. The temporal evolution of the intensity is in agreement with the model of an impulsively generated, fast-mode wave.

Thesis-related Publications: A&A 351, L23 (1999); Solar Physics 195, 367 (2000); MNRAS 326, 428 (2001); MNRAS in press (2002)

Dependence of the Magnetic Activity on Subphotospheric Convection Properties and Stellar Rotation in Late-type Stars

Nicola Pizzolato

Thesis work conducted at: Osservatorio Astronomico G.S. Vaiana di Palermo, ITALY

Current address: Osservatorio Astronimico G.S. Vaiana di Palermo, Piazza del Parlamento 1, 90134 Palermo, ITALY

E-mail: nicola@oapa.astropa.unipa.it

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

Ph.D degree awarded: February 2002

This research thesis is devoted to study the dependence of the X-ray emission in late-type main-sequence stars on the properties of the stellar internal structure and on the stellar rotation rate. Such a dependence is expected because stellar coronae are currently understood as the end result of a magnetic dynamo mechanism, which operates in a highly conductive fluid (plasma) subject to convective and rotational motions. Characteristic time scales of such motions are the convective turnover time - i.e. the period of circulation within a convective cell spanning from the bottom to the top of the convection zone - and the stellar rotation period. In fact, the efficiency of the dynamo is often parameterized as a function of the adimensional Rossby number, the ratio of the above two time scales. Any physical mechanism acting on these time scales is expected to influence the generation of magnetic fields and, eventually, the heating of the coronal plasma and the X-ray emission level.

In the past two decades many scientists (cited in Chapter 1) have investigated the dependence of the coronal and chromospheric emission levels on the stellar spectral class, age or chemical composition in different samples of late-type stars, by adopting the Rossby number as the parameter best suited to estimate the level of stellar magnetic activity. In these works, however, the Rossby number was always calculated as the ratio of the rotation period, a measured quantity, and the convective turnover time calculated as an empirically-derived function of the stellar spectral type. Moreover, although this function was originally derived for main-sequence stars with well defined characteristics, several authors have applied such empirical Rossby number out of this range of applicability.

In this respect, we have adopted a new approach in the study of the dependence of the coronal X-ray emission on stellar parameters, such as the plasma metallicity (i.e. the abundance of heavy elements), the stellar mass and age, and the rotation period itself. We have employed both theoretical models of the stellar internal structure (in particular, of the characteristics of the subphotospheric convection zone), and selected X-ray observations of field stars and stars in galactic open clusters.

Our results suggest that the influence of the metallicity on the properties of the convective motions, and ultimately on the X-ray emission, is more important for solar-type stars (late F or G type) than for stars of lower mass (K and M type); comparison with observational data partially confirms this expectation, but more stringent tests are required (which are currently not possible because of the lack of sufficient data).

We also show that the rotation period by itself appears to be a good predictor of the stellar X-ray luminosity down to a critical value, below which the coronal emission reaches a saturation level; both the critical period and the saturation X-ray luminosity depend on the stellar mass, in a way that we have quantitatively described based on a stellar sample larger and more complete than in previous studies. A unique, mass-independent description can be obtained by employing the X-ray to bolometric luminosity ratio vs. an empirical Rossby number, that we have computed as the ratio of the observed rotation period to an empirically-estimated time scale that we have derived from the data themselves. We show that this empirical quantity, which depends on the stellar $B-V$ color (i.e. on

mass) coincides essentially with the theoretically-computed convective turnover time scale up to $B-V \sim 1.2$, but it is significantly lower for redder stars. We discuss this finding and suggest other possible interpretations of this empirical time scale.

Thesis-related Publications: A&A 373, 597; ApJ, 547, L141

Announcements

New Review Article on Stellar Radio Astronomy

Stellar Radio Astronomy. Probing Stellar Atmospheres from Protostars to Giants

Manuel Güdel

Paul Scherrer Institut, Würenlingen & Villigen, CH-5232 Villigen PSI, Switzerland

Radio astronomy has provided evidence for the presence of ionized atmospheres around almost all classes of non-degenerate stars. Magnetically confined coronae dominate in the cool half of the Hertzsprung-Russell diagram. Their radio emission is predominantly of non-thermal origin and has been identified as gyrosynchrotron radiation from mildly relativistic electrons, apart from some coherent emission mechanisms. Ionized winds are found in hot stars and in red giants. They are detected through their thermal, optically thick radiation, but synchrotron emission has been found in many systems as well. The latter is emitted presumably by shock-accelerated electrons in weak magnetic fields in the outer wind regions. Radio emission is also frequently detected in pre-main sequence stars and protostars, and has recently been discovered in brown dwarfs. This review summarizes the radio view of the atmospheres of non-degenerate stars, focusing on energy release physics in cool coronal stars, wind phenomenology in hot stars and cool giants, and emission observed from young and forming stars.

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For preprints contact: guedel@astro.phys.ethz.ch

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Schedule: Electronic article publication in *Reviews in Advance* (for subscribers): check WWW
full electronic publication (for subscribers): ~ 8/18/2002
http://astro.annualreviews.org/
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http://astro.annualreviews.org/pap_articles.shtml

full print publication: ~ 9/22/2002

UPCOMING MEETING

Workshop on 3-D Stellar Evolution

July 22 - 26, 2002
UC Davis
Livermore, CA

A workshop on "3-D Stellar Evolution" will be held at the UC Davis Department of Applied Science in Livermore (CA) on the week of the 22nd to 26th July 2002.

The workshop will be devoted to numerical and observational aspects of the study of stars as 3-D objects. Topical sessions will include: Helioseismology; Computational algorithms; Brown Dwarfs; Binary stars; Red giant atmospheres; Solar physics: turbulence, magnetism, rotation, oscillations; Protostars, ...

For more details please visit the workshop website at http://www.llnl.gov/urp/igpp/3DStar/

Submitted by:

Sylvain Turcotte
Lawrence Livermore National Laboratory
sturcotte@igpp.ucllnl.org
Tel. (925) 422-0826
Fax. (925) 423-0238

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` .