COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 3 — November 1995 Editor: Steve Skinner (coolnews@jila.colorado.edu)

TABLE OF CONTENTS

Stellar Abstracts 2
Solar Abstracts 7
Ph.D. Thesis Abstract (Hugh Jones) 11
Ph.D. Thesis Abstract (Leila Belkora) 12
Meeting Summary: 9th Cambridge Workshop 13
Meeting Summary: Stellar Surface Structure 14
Announcement: Inputs Solicited for NOAO Forum 14
Abstract Guidelines 15

On the Determination of Empirical Stellar Flux Scales

Jeffrey C. Hall[1]

[1] Lowell Observatory, 1400 W. Mars Hill Rd., Flagstaff, AZ 86001 USA

Several studies have appeared in the literature describing methods for deriving stellar continuum fluxes as simple functions of Johnson color indices. In previous papers, we have used similar relations to derive Ca II H & K line core fluxes for dwarf stars on Lowell Observatory's Solar-Stellar Spectrograph (SSS) program. Our desire is to present our data, and complementary data from the Mt. Wilson and National Solar Observatory stellar and solar programs, in terms of physical fluxes. However, our existing relations break down for mid-K and later stars and for giant stars, which form an important element of our target list. In this work I have used a broader range of spectrophotometry and angular diameters than in our previous work to derive empirical flux scales for a variety of spectral types and luminosity classes, and for four color indices, Johnson $B-V$, $V-R$, $R-I$, and Strömgren $b-y$. In this paper I describe the methods I used and present the derived flux scales, compare the results with those from earlier studies, and present examples of the use of the flux scales. The results will be made available on the WWW.

Accepted by PASP

For preprints contact: jch@lowell.edu

Application of the Spectral Subtraction Technique to the Ca II H & K and Hϵ Lines in a Sample of Chromospherically Active Binaries

D. Montes[1], **E. De Castro**[1], **M.J. Fernández-Figueroa**[1] **and M. Cornide**[1]

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

We present new spectroscopic observations in the Ca II H & K line region for a sample of 28 chromospherically active binary systems (RS CVn and BY Dra classes), with different activity levels. By using the spectral subtraction technique (subtraction of a synthesized stellar spectrum constructed from reference stars of similar spectral type and luminosity class) we obtain the active-chromosphere contribution to the Ca II H & K lines and to the Hϵ line when it is present. We have compared the emission equivalent widths obtained with this technique with those obtained by reconstruction of the absorption line profile below the emission peak(s).

The emissions arising from each individual star were obtained when it was possible to deblend the contribution of both components. The Ca II line profiles corresponding to different seasons and orbital phases are analysed in order to determine the contribution of each component and to study the chromospheric activity variations.

Accepted by A&A Supp.

For preprints contact: dmg@ucmast.fis.ucm.es

For preprints via ftp or WWW: http://www.ucm.es/OTROS/Astrof/dpto_preprints.html

Optical Spectra of ζ Aurigae Systems – VIII. The Chromosphere of HR 6902

K.-P. Schroeder[1,2], **K.P. Marshall**[1], **R.E.M. Griffin**[1]

[1] Institute of Astronomy, Madingley Road, Cambridge CB30HA, UK
[2] Hamburger Sternwarte, Gojenbergsweg 112, D–21029 Hamburg, Germany

We analyze chromospheric spectra of the ζ Aur system HR 6902 observed during its 1987 and 1989 eclipses, deriving empirical column densities, number densities and ionization characteristics for 5 distinct heights within the giant primary's chromosphere. Column densities for Ca II are determined from K-line profiles and for other ions by a curve-of-growth technique, modelling iteratively the scale heights of the line-forming regions according to the known geometry of the eclipses and dimensions of the system. We find evidence for the existence of two plasma components in and beyond the chromosphere that are physically different. The inner component has a low turbulence ($v_{tur} = 15$ km s^{-1}); its ion column densities decrease steeply outwards and seem to outline the geometrically-thin chromosphere

itself. There is some evidence that the geometical extent of this component varies from one eclipse to another. The outer component has a significantly higher turbulence ($v_{tur} = 45$ km s^{-1}) and a scale height that is nearly an order of magnitude larger. Because its column density is much lower, we have only been able to observe it by our technique in the strongest chromospheric lines (i.e. Ca II); it extends much farther outwards than the inner component – probably into regions beyond the top of the chromosphere, for which IUE observations give evidence of plasma at transition-region temperatures ($\approx 10^5$).

We consider the evolutionary status of the two components, and conclude that the primary star is an ordinary 3.9 $M_\odot$ blue-loop giant that is 2.0 10^8 years old. We compare the chromosphere of HR 6902 with those of other ζ Aur giants and discuss the meaning of the 'dividing lines' as tracers of the very different conditions which are encountered in G and K (super)giant chromospheres.

Submitted to A&A

For preprints contact: schroder@ast.cam.ac.uk

Lithium Processing in Halo Dwarfs, and $T_{\rm eff}$, [Fe/H] Correlations on the Spite Plateau

Sean G. Ryan[1,2], Timothy C. Beers[3], Constantine P. Deliyannis[4,5] and Julie A. Thorburn[6]

[1] Present address: Anglo–Australian Observatory, P O Box 296, Epping, NSW 2121, Australia
[2] Department of Physics and Astronomy, University of Victoria, P O Box 3055, Victoria BC V8W 3P6, Canada
[3] Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824
[4] Present address: Center for Solar and Space Research, Center for Theoretical Physics, and Department of Astronomy, Yale University, P.O. Box 208101, New Haven, CT 06520-8101
[5] Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822
[6] Yerkes Observatory, P. O. Box 258, Williams Bay, WI 53191-0258

We present new Li data for 7 halo turnoff stars chosen to test for diffusion. These are combined with data from the literature, and new effective temperatures and Li abundances are computed for the entire set on uniform temperature and abundance scales. We conclude that the effects expected of diffusion are not obvious in warm halo dwarfs, and uninhibited diffusion is unlikely to result in an initial Li abundance more than 0.1 dex higher than that inferred from non–diffusive models. (*Other* mechanisms for depleting Li, possibly by substantially larger amounts, are still possible.)

We consider the ongoing debate concerning the existence of correlations between the Li abundances for metal–poor stars and $T_{\rm eff}$ and overall metallicity, [Fe/H]. Molaro, Primas, & Bonafacio (1995, A&A, 295, L47) argue that previously-reported slopes in the plateau as a function of these two variables (Thorburn 1994, ApJ, 421, 318; Norris, Ryan, & Stringfellow 1994, ApJ, 423, 386) disappear when a subset of stars with temperatures based on Balmer line profiles is adopted. Upon closer examination of the Molaro et al. data and our own newly expanded data, we find that these correlations persist, but several points are worth noting: (a) suspected subgiants should be eliminated from the sample, (b) metallicity trends are evident only when stars of a wide range of metal abundances are included in the samples, especially the most metal–poor stars, (c) the tests must be performed in a multiple–regression environment (i.e., not when $T_{\rm eff}$ or [Fe/H] is considered the only independent variable), and (d) the results survive when robust regression methods are applied. Our current best estimate of the mean Li abundance as a function of $T_{\rm eff}$ and [Fe/H] is:

$$A(\mathrm{Li}) \;=\; -0.09(\pm 0.30) \;+\; 0.0408(\pm 0.0052) * T_{\rm eff}/100 \;+\; 0.111(\pm 0.018) * [\mathrm{Fe/H}]$$

The slopes of this relationship are consistent, within expected errors, with the results of Thorburn (1994) and Norris et al. (1994). The reported correlations appear to be real, in contradiction to the claim of Molaro et al. (1995).

We identify rare cases of well–observed stars with similar temperatures and metallicities which cannot have the same Li abundance; the contrast between G64-12, G64-37 and CD-33:1173 provides the best example. However we defer our main discussion on a possible intrinsic spread in the Spite plateau to a separate paper.

Accepted by ApJ (to appear 20 February 1996)

For preprints contact: sgr@aaoepp.aao.gov.au

Spot Modelling for Binaries with Two Active Components

Zs. Kővári [1] and K. Oláh [1]

[1] Konkoly Observatory of the Hungarian Academy of Sciences, P.O. Box 67, Budapest, 1525, Hungary

A method is presented to model light variation caused by spots in binary systems with two spotted components. The reference light level of the binary is divided between the two components by their fractional luminosities. Spot models of the two stars were separately performed and the results combined. Spot temperatures can be determined on both components separately. We tested our method modelling light curves of BY Dra from the years 1965, 1988 and 1991. Using this method the problem of modelling the large amplitude light variation at the lowest system brightness in 1965 was solved.

Accepted by A&A

For preprints contact: kovari@buda.konkoly.hu

A Survey of Ca II H and K Chromospheric Emission in Southern Solar-Type Stars

Todd J. Henry[1], David R. Soderblom[1] Robert A. Donahue[2] and Sallie L. Baliunas[2]

[1] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218 USA
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138 USA

More than 800 southern stars within 50 pc have been observed for chromospheric emission in the cores of the Ca II H and K lines. Most of the sample targets were selected to be G dwarfs on the basis of colors and spectral types. The bimodal distribution in stellar activity first noted in a sample of northern stars by Vaughan and Preston in 1980 is confirmed, and the percentage of active stars, about 30%, is remarkably consistent between the northern and southern surveys. This is especially compelling given that we have used an entirely different instrumental setup and stellar sample than used in the previous study. Comparisons to the Sun, a relatively inactive star, show that most nearby solar-type stars have a similar activity level, and presumably a similar age.

We identify two additional subsamples of stars – a very active group, and a very inactive group. The very active group may be made up of young stars near the Sun, accounting for only a few percent of the sample, and appear to be less than ~0.1 Gyr old. Included in this high-activity tail of the distribution, however, is a subset of very close binaries of the RS CVn or W UMa types. The remaining members of this population may be undetected close binaries or very young single stars. The very inactive group of stars, contributing ~5-10% to the total sample, may be those caught during a Maunder Minimum type phase. If the observations of the survey stars are considered to be a sequence of snapshots of the Sun during its life, we might expect that the Sun will spend about 10% of the remainder of its main sequence life in a Maunder Minimum phase.

Accepted by AJ

For preprints contact: thenry@stsci.edu

A Search for Lithium in Cataclysmic Binaries

E.L. Martín[1], J. Casares[2], P.A. Charles[2] and R. Rebolo[1]

[1] Instituto de Astrofísica de Canarias, E-38200 La Laguna, Tenerife, Spain
[2] University of Oxford, Department of Physics, Nuclear Physics Laboratory, Keble Road, Oxford, OX1 3RH, UK

The discovery of lithium in the late type secondaries of several black hole binaries has motivated considerable interest in the presence of this light element in stars orbiting compact objects in general. We report here on a search for Li in cataclysmic binaries (CVs), where a low mass star transfers mass onto a white dwarf. For this purpose, we have taken spectra in the Li region of eight CVs, and we have also compiled existing data.

In eight CVs with visible photospheric absorption lines from the secondary, we find no evidence for Li. Our upper limits to the Li abundance in these CVs are lower than the abundance found in the secondaries of black holes by factors in the range 2 to 300. The implications for understanding the Li observed in several X-ray transients, are discussed. One of the CVs that we have observed, GK Per, is known to have undergone a recent nova outburst (Nova Persei 1901), and hence our observations do not support models predicting large Li production in classical novae.

Accepted by A&A

For preprints contact: ege@iac.es

Cool Prominences in the Corona of the Rapidly Rotating dMe Star, HK Aqr

P.B. Byrne[1], M.T. Eibe[1], W.R.J. Rolleston[1]

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

We report the discovery of cool, prominence-like material embedded in the hot corona of the rapidly rotating dMe flare/spot variable, HK Aqr. Using these observations we demonstrate that, unlike the case of the rapidly rotating K dwarf, AB Dor, these features do not form at the co-rotation radius. Rather they have dimensions larger than, but comparable to, the very largest solar prominences. At least seven clouds were detected during each stellar rotation and they have a lifetime of greater than the three nights spanned by our data.

Submitted to A&A

For preprints contact: pbb@star.arm.ac.uk

Photometric and Spectroscopic Studies of Cool Stars Discovered in EXOSAT X-ray images. III. Photometric Properties

G. Cutispoto[1], G. Tagliaferri[2], R. Pallavicini[3], L. Pasquini[4] and M. Rodonò[1,5]

[1] Osservatorio Astrofisico di Catania, v.le A. Doria 6, I-95125 Catania, Italy
[2] Osservatorio Astronomico di Brera, v. Bianchi 46, I-20121 Merate, Italy
[3] Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
[4] European Southern Observatory, Casilla 19001, Santiago 19, Chile
[5] Istituto di Astronomia, Università degli Studi, I-95125 Catania, Italy

We present high-precision UBV(RI)c photometry for a sample of active stars detected serendipitously by the EXOSAT satellite. Fourteen objects, out of 47 likely optical counterparts, turned out to be clearly variable, with periods in the range 1-8 days, including a newly discovered eclipsing binary. For most of them the optical variability is consistent with the presence of photospheric cool spots. We have used our multicolor photometry to estimate spectral classification and distances. The derived distances indicate that some of the observed stars are previously unidentified nearby (d$\leq$25 pc) M dwarfs. When combined with the results of high resolution spectroscopy, our photometric observations allow us to investigate the stellar content of the selected X-ray sample. Young stars and RS CVn-type binaries appear to constitute a large fraction of the selected sample

Accepted by A&A Supp.

For preprints contact: gcutispoto@astrct.ct.astro.it

Tables 2 and 3 are available at the CDS via anonymous ftp: 130.79.128.5

Spectra of Late Type Stars from 4800 to 9000 Å

M. Serote Roos[1,2], C. Boisson[1] and M. Joly[1]

[1] DAEC, Observatoire de Paris, Université Paris VII, CNRS (UA 173), F–92195 Meudon Cedex, France
[2] Centro de Astrofisica, Universidade do Porto, Rua do Campo Alegre, 823, 4100 Porto, Portugal

We present optical spectra of 21 stars from 4800 to 8920 Å, covering essentially the late spectral types, G, K, M and the luminosity classes I and III. Half of the stars are super metal rich (SMR) ones. The spectra were obtained at a resolution of 1.25 Å using the Aurelie spectrograph, equipped with a linear array CCD-like detector, attached to OHP 1.52 m telescope.

Also presented are the spectra of 7 stars, covering the region 5000-9783 Å at a resolution of 8.5 Å , observed at the CFHT with the Herzberg spectrograph. The spectral types are F, G, K, M and the luminosity classes III and V. Five stars are SMR.

These spectra have been obtained in the aim of extending existing libraries used for population synthesis purposes. The inclusion of SMR stars in a stellar library dedicated to the study of stellar populations in the central part of galaxies is crucial as abundance gradients have been observed in the optical range.

We have measured the equivalent widths of the main absorption features which agree with the previously known correlations with temperature and surface gravity thus attesting to the quality and utility of the data for stellar population synthesis.

A digital version with all the spectra presented is available in electronic form via the CDS in Strasbourg, France.

Accepted by A&A Supp.

For preprints contact: serote@daec.obspm.fr

ROSAT X-ray Observations of a Complete, Volume-limited Sample of Late-type Giants

M. Hünsch[1], J.H.M.M. Schmitt[2], K.-P. Schröder[1,3], and D. Reimers[1]

[1] Hamburger Sternwarte, Universität Hamburg, Gojenbergsweg 112, 21029 Hamburg, Germany
[2] Max-Planck-Institut für Extraterrestrische Physik, 85748 Garching, Germany
[3] Institute of Astronomy, Madingley Road, Cambridge CB3 0HA, UK

We have investigated a complete sample of the nearest 39 late-type giants (d $\leq$ 25 pc) for which we have probed the X-ray luminosity function with unprecedented sensitivity by deep (3...18 ksec.) ROSAT PSPC-observations in the pointed mode, together with ROSAT all-sky survey data. We confirm the X-ray dividing line for luminosity class III giants as proposed by Haisch et al. (Nat. 360, 239 (1992)) and we find evidence that essentially *all* luminosity class III giants with B–V $<$ 1.2 or spectral type $<$ K3, that is to the hot side of the X-ray dividing line in the HR diagram, show X-ray emission with typical luminosities of about 10^{27} erg s^{-1}. A few stars like β Cet have considerably higher X-ray luminosities. On the right, cool side of the X-ray dividing line, we find only one X-ray emitting star in our sample, while the other stars have upper limits for their ratios of X-ray to bolometric luminosities as low as $\log L_{\rm x}/L_{\rm bol} \leq -10$. We find observational evidence for a minimum X-ray surface flux to the left of the dividing line of the order of $\approx$ 100 erg cm^{-2} s^{-1}, which seems to be independent of B–V colour. The data and their implications for our understanding of coronae of late-type giants, in particular the questions concerning the dividing lines and possible acoustic heating of the coronae are discussed in some detail.

Accepted by A&A

For preprints contact: mhuensch@hs.uni-hamburg.de

Hybrid Stars and the Reality of "Dividing Lines" Among G to K Bright Giants and Supergiants

D. Reimers[1], M. Hünsch[1], J.H.M.M. Schmitt[2], and F. Toussaint[1]

[1] Hamburger Sternwarte, Universität Hamburg, Gojenbergsweg 112, 21029 Hamburg, Germany
[2] Max-Planck-Institut für Extraterrestrische Physik, 85748 Garching, Germany

We present results of pointed ROSAT PSPC observations of 15 hybrid stars/candidates, which have been analyzed in a homogeneous way. Seven of these stars were observed in X-rays for the first time.

Twelve out of 15 hybrid stars have been detected as X-ray sources, some of them close to the detection limit. We conclude that essentially all hybrid stars as defined by the simultaneous presence of transition region line emission and cool stellar winds are X-ray sources if exposed sufficiently deep.

The X-ray luminosities of hybrid stars cover a range between $2 \cdot 10^{27}$ and $\sim 10^{30}$ erg s^{-1}. Their X-ray surface fluxes can be as low as $\approx$20 erg cm^{-2} s^{-1} and thus considerably lower than that of normal LC III giants, moreover, the X-ray brightest stars have the hardest spectra.

We find that for K II giants the normalized X-ray flux versus C IV flux obeys a power law with an exponent a=2.9, steeper than among normal giants (1.5). Hybrid K II stars are X-ray underluminous by a factor of 5 to 20 compared to LC III giants at the same level of normalized C IV flux $f_{\rm CV}/f_{\rm bol}$; hybrid G supergiants are even more X-ray deficient.

We reanalyze the Ca II wind dividing line and find it vertical at B–V=1.45 for LC III giants. It is nearly horizontal between B–V=1.45 and 1.0 (at $M_{\rm bol} \approx$ –2...–3), and not well defined for supergiants with B–V<1.0.

We therefore suggest that possibly all LC II and Ib G and K giants are hybrid stars and that the "dividing line" concept in its simplest form is not valid for G/K giants brighter than $M_{bol} \approx -2$.

Hybrid stars are supposed to be evolved intermediate mass stars and their coronal activity may in principle be determined by the individual history of each star.

Accepted by A&A

For preprints contact: dreimers@hs.uni-hamburg.de

Solar Abstracts

Coronal Heating, Densities, and Temperatures and Solar Wind Acceleration

V. H. Hansteen[1,2], E. Leer[2,1]

[1] High Altitude Observatory, National Center for Atmospheric Research, PO Box 3000, Boulder Colorado 80307-3000
[2] Institute of Theoretical Astrophysics, University of Oslo, PO Box 1029 Blindern, N-0315 Oslo, Norway

The outflow of coronal plasma into interplanetary space is a consequence of the coronal heating process. Therefore the formation of the corona and the acceleration of the solar wind should be treated as a single problem. Traditionally the mass or particle flux emanating from the extended corona has been thought of as being determined by the coronal temperature or scale height and the coronal (base) density. This argument follows from considerations of the momentum balance of the corona–wind system from which one obtains models of a close to hydrostatic corona out to the critical point where the flow becomes supersonic. With this approach to the acceleration of the wind it has been difficult to reconcile the relatively small variation observed in the proton flux at 1AU with the predicted exponential dependence of the proton flux on the coronal temperature. In this paper we would like to emphasize another approach in which coronal energetics play the primary role: The deposition of energy into the corona through some "mechanical" energy flux is balanced by the various energy sinks available to the corona, and the sum of these processes determines the coronal structure, i.e., its temperature and density. The corona loses energy through heat conduction into the transition region and through the gravitational potential energy and kinetic energy put into the solar wind. We show from a series of models of the chromosphere–transition region–corona–solar wind system that most of the energy deposited in a magnetically open region goes into the solar wind. The transition region pressures and the coronal density and temperature structure may vary considerably with the mode and location of energy deposition, but the solar wind mass flux is relatively insensitive to these variations; it is determined by the amplitude of the energy flux. In these models the transition region pressure decreases in accordance with the increasing coronal density scale height such that the solar wind mass loss is consistent with the energy flux deposited in the corona. On the basis of the present study we can conclude that the exponential increase of solar wind mass flux with coronal temperature, found in most thermally driven solar wind models, is a consequence of fixing the transition region pressure.

Accepted by J. Geophys. Res.

For preprints contact: Viggo.Hansteen@astro.uio.no

Observation of Infrared Lines in a Prominence at 1 - 5 Microns

Edward S. Chang[1] and Drake Deming[2]

[1] Department of Physics & Astronomy, University of Massachusetts, Amherst, MA 01003 USA
[2] Code 693, NASA/Goddard Space Flight center, Greenbelt, MD 20771 USA

We have observed 11 hydrogen and 3 helium lines in a quiescent prominence; none have been previously observed except for the He 10830 line. In contrast to Zirker's results based on longer wavelength infrared lines, we find no net velocity shift, Doppler widths narrower than his by more than 30%, and a hydrogen excitation temperature 3 times higher. From the line intensity method, we find a helium temperature of 5300(200) K and a hydrogen temperature of 10,900(1900) K, in reasonable agreement with the findings of visible line studies. We conclude that helium lines are formed in the central region while hydrogen lines are formed around the edges of the prominence.

Submitted to Solar Physics

For preprints contact: chang@phast.umass.edu

Quiet Sun Connection Between the C IV Resonance Lines and the Photospheric Magnetic Field

Nils Brynildsen[1], **Olav Kjeldseth-Moe**[1], **and Per Maltby**[1]

[1] Institute of Theoretical Astrophysics, University of Oslo, P.O.Box 1029, Blindern, N-0315 Oslo, Norway

The quiet Sun relation between the C IV resonance line parameters and the photospheric magnetic field is studied with a spatial resolution of $1'' \times 1''$. The material is ordered into groups according to the magnitude of the magnetic flux density |B|, and conditional probabilities are calculated. We find that redshifted profiles with either high intensity, large Doppler shift, or large line broadening occupy an increasing fraction of the area when |B| increases. These results are contrasted by blueshifted profiles which indicate a slight decrease with increasing magnetic flux density. The similarity in the results obtained with magnetograms taken several hours before and after the UV data led us to suggest that the tendency for redshifted profiles to outnumber blueshifted profiles in quiet regions originates in the supergranular network.

Suggestions regarding the origin of the redshift phenomenon are briefly confronted with the observations. It appears difficult to explain the observations with models based on continuous gas flows. However, a model containing Alfvén wave pulses traveling from the corona towards the transition region promises to be compatible with the observations.

Accepted by ApJ

For preprints contact: per.maltby@astro.uio.no

An Asymptotic Description of Solar Acoustic Oscillations of Low and Intermediate Degree

I. W. Roxburgh[1] **and S. V. Vorontsov**[1,2]

[1] Astronomy Unit, Queen Mary and Westfield College, University of London, Mile End Road, London E1 4NS, UK
[2] Institute of Physics of the Earth, B. Gruzinskaya 10, Moscow 123810, Russia

We present an asymptotic description of high-frequency solar p modes which permits an accurate treatment of regions where the seismic parameters vary rapidly with depth, and incorporates the strong effect of gravity perturbations on low-degree modes. The description is based on an asymptotic reduction of the governing fourth-order system of linear differential equations to second order. Approximate solutions of the second-order equation are then developed using a Born-type asymptotic expansion. The accuracy of the resulting description is tested numerically on a standard solar model. Higher-order Born approximations give fractional accuracies of at least 10^{-3}.

Accepted by MNRAS

For preprints contact: I.W.Roxburgh@qmw.ac.uk

Force-free Thin Flux Tubes: Basic Equations and Stability

Y.D. Zhugzhda[1,2]

[1] Institut für Theoretische Astrophysik der Universität Heidelberg, Tiergartenstrasse 15, D–69121 Heidelberg, Germany
[2] Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of the Russian Academy of Sciences, Troitsk, Moscow Region, 142092, Russia

The thin flux tube approximation is considered for a straight, symmetrical, force-free, rigidly rotating flux tube. The derived set of equations describes tube, body sausage, and Alfven wave modes and is valid for any values of β. The linear waves and instabilities of force-free flux tubes are considered. A comparison of approximate and exact solutions for an untwisted, non-rotating flux tube is performed. It is shown that the approximate and exact dispersion equations coincide except for a 20 percent discrepancy of sausage frequencies. An effective cross section is proposed to remove this discrepancy. It makes the derived approximation correct for the force-free thin flux tube dynamics except for the detailed structure of the radial eigenfunction. The dispersion of Alfven torsional waves in a force-free tube appears. The valve effect of one directional propagation of waves in a rotating twisted tube is revealed. The current and

rotational sausage instabilities of a force-free, thin flux tube are considered.

Accepted by Physics of Plasmas

For preprints contact: zhu@artemis.ita.uni-heidelberg.de

Elemental Abundances in the Solar Network and Cell Centers from EUV Spectra

D. Spadaro[1], F. Zuccarello[2] and R.A. Zappala[2]

[1] Osservatorio Astrofisico di Catania, I-95125 Catania, Italy
[2] Istituto di Astronomia dell'Università, I-95125 Catania, Italy

In order to search for empirical evidences in the transition region and corona explaining the observed variability of the chemical composition in the solar wind, we have used a set of EUV average spectra in the 296 – 1350 Å wavelength range (Vernazza & Reeves 1978), to determine the relative abundances of C, N, O, Ne, Mg, Si, S in the cell centers and the network within a coronal hole and a quiet region, respectively. Moreover, we have determined the relative abundances in an active region during two periods characterized by different activity levels. The analysis has shown that the elemental abundances appear in broad agreement with the photospheric ones for all the different regions examined. Moreover, within the coronal hole and the quiet region, the chemical composition in the cell centers does not differ appreciably from that in the network. Further, no differences in the elemental abundances have been found in the active region during the two considered phases. Nevertheless, we point out that the data used in this analysis for a given kind of structure are composed of spectra taken at various times and positions within the same region, so that eventual differences may be smoothed out by temporal and spatial averages. We discuss the implications of the results concerning the cell centers and the network for the ion–neutral separation model suggested by Meyer (1991).

Accepted by A&A

For preprints contact: dspadaro@astrct.ct.astro.it

EUV Spectral Lines from Solar Wind Source Regions: the Resonance Doublets of N V, Mg X and Si XII, and the Fe XII $\lambda1242$ Forbidden Line

D. Spadaro[1], R. Ventura[1]

[1] Osservatorio Astrofisico di Catania, CNR-Gruppo Nazionale di Astronomia, UdR di Catania, Città Universitaria, Viale A.Doria, 6 I-95125, Catania, Italy

We present numerical simulations of intensities and profiles of the N V $\lambda1239$ and $\lambda1243$, Mg X $\lambda610$ and $\lambda625$, Si XII $\lambda499$ and $\lambda521$, and Fe XII $\lambda1242$ lines expected from an equatorial and polar coronal hole at solar minimum, when observed on the plane of the sky in the $1.2R_\odot$ – $8R_\odot$ range of heliocentric distance. The radial variations of coronal temperatures, densities and outflow speeds inside these structures are those determined by Withbroe (1988) through a one–fluid steady–state radiative energy balance model. We discuss how the spectral features depend on the physical parameters of the examined structures, in order to evaluate to which extent they can put constraints on empirical models of the extended corona. We also investigate the effects of the deviations from ionization equilibrium occurring in the plasma outflowing from the considered coronal structures on the intensity and profile of the spectral lines examined. Such effects become significant at heliocentric distances higher than $3R_\odot$. These results may contribute to the preparation and interpretation of future UVCS/SOHO observations.

Accepted by A&A

For preprints contact: dspadaro@astrct.ct.astro.it

A Study of the Unresolved Fine Structure Model for the Solar Transition Region

D. Spadaro [1], A.F. Lanza [1], and S.K. Antiochos [2]

[1] Osservatorio Astrofisico di Catania, Città Universitaria, Catania, Italy
[2] E.O. Hulburt Center for Space Research, Naval Research Laboratory, Washington, D.C.

The Unresolved Fine Structure (UFS) model for the lower transition region was proposed by Feldman (1983) as an explanation for a number of puzzling observational results, specifically, the small filling factor of this region, the inability of the observations to resolve the temperature structure, and the observation of persistent redshifted UV emission lines even near the solar limb. It was hypothesized that opacity effects may be able to explain the redshift observations. We consider a simple model for the UFS consisting of a plasma sphere undergoing expansion and contraction due to a time-varying heating. We calculate in detail the line profile of the well-observed C IV 1548 Å line. Our calculations include the effects of both non-equilibrium ionization and radiative transfer. We find that although the model can reproduce some of the features of the observations, such as the line widths, the effect of finite optical depth is to produce a blueshifted peak for the emission line, contrary to observations. The physical origins of this blueshift are discussed. We conclude that unless the pressures of the UFS are significantly higher than the typical pressures assumed for the lower transition region, opacity effects are unlikely to explain the observations.

Accepted by ApJ

For preprints contact: dspadaro@astrct.ct.astro.it

Ph.D. Thesis Abstract

Infrared and Optical Studies of Cool Low-mass Dwarfs

Hugh R.A. Jones

Thesis work conducted at: Institute for Astronomy, Royal Observatory, Scotland

Current address: Astrophysics Group, Liverpool John Moores University, Byrom Street, Liverpool, L3 3AF, UK

E-mail: hraj@staru1.livjm.ac.uk

Ph.D dissertation directed by: Andrew J. Longmore

Ph.D degree awarded: June 1995

Infrared and optical studies of cool low-mass dwarfs are made in order to determine their properties. The goal of distinguishing low-mass stars from brown dwarfs is engaged by studies on a number of different fronts.

(1) The first infrared spectral sequence of cool dwarfs from GL411 (M2V) to GD165B (>M10V) enables derivation of reliable bolometric luminosities down to the hydrogen burning limit. The strength of the deep water absorption bands is used as the basis of a new reliable method to calculate effective temperatures. We find that GD165B is the only star in the sample that is a good brown dwarf candidate.

(2) Expected temperatures, metallicities and gravities of cool dwarfs are compared to inferences from fitting synthetic to observed spectra at the peak of the energy distribution. A good representation of the overall spectral features is found, although the study is limited by (i) the quality of atomic and molecular opacities and (ii) the complex behaviour of atomic lines having strengths which *increase* with decreasing metallicity down to around −1.5 dex. The comparisons suggest a similar spread in metallicities to that anticipated, although for our sample neither kinematic motion nor membership of a particular photometric class are, on their own, reliable indicators of metallicity.

(3) A high resolution study of the strongest water vapour absorption band in cool dwarfs is compared to predictions from a preliminary *ab initio* computation for water vapour incorporated into a stellar atmosphere calculation. The comparisons show that water vapour lines are formed relatively high in the photosphere at pressures about an order of magnitude lower than atomic lines. The overestimated pressure broadening of water vapour, and probably other molecular lines, is likely to explain much of the past discrepancy between observed and theoretical spectral energy distributions.

(4) The discovery is reported of the reddest known brown dwarf candidate. Classification as a star or a brown dwarf depends on the adopted age and the evolutionary model used. Its discovery within an infrared field survey places the first lower limit on the space density for objects fainter than $M_{\mathrm{bol}} = 14$ and suggests that the luminosity function does not fall dramatically into the brown dwarf regime.

Thesis-related Publications: MNRAS, 267, 413; MNRAS, 270, L47; MNRAS, in press; MNRAS, submitted

Ph.D. Thesis Abstract

Interferometric Studies of the Sun at Microwave and Millimeter Wavelengths

Leila A. Belkora

Thesis work conducted at: APAS Department, University of Colorado, Boulder, CO, USA, and California Institute of Technology, Pasadena, CA, USA

Current address: Mail Station 206, Fermilab, P.O. Box 500, Batavia IL 60510 USA

E-mail: lbelkora@fnal.gov

Ph.D dissertation directed by: Frances Bagenal

Ph.D degree awarded: September 1995

The work presented in this thesis relied mainly upon two radio interferometers, the Owens Valley Solar Array and the Owens Valley Millimeter Array. I used the Owens Valley Millimeter Array during the eclipse of July 11, 1991 to observe the brightness temperature profile of the solar limb. These observations showed that photospheric-temperature gas exists at an altitude of about 5500 km above the visible photosphere, far beyond the expected location of the transition region where the temperature increases to about one million degrees. I proposed that this result can be explained in terms of a two-component model of the upper chromosphere. Spicules would compose a relatively cool and dense component embedded in a hot, tenuous medium like that described by the so-called VAL model (Vernazza, Avrett, and Loeser 1981).

Later I used data from the Solar Array to make a detailed investigation of the gyrosynchrotron spectrum of the flare of July 16 1992. The results of this investigation led me to propose a solution to a long-standing problem in solar microwave bursts, that of the constant peak frequency of the bursts as they evolve in brightness temperature, and the steep slope on the low-frequency side of the spectrum. I proposed that the Razin effect is at work, and I developed the theory of Razin suppression for solar microwave burst conditions. The Razin effect is the suppression of radiation from an electron in a medium in which the index of refraction is less than unity. I demonstrated that in a medium with density $2 \times 10^{11}\,\mathrm{cm}^{-3}$ and magnetic field 300 Gauss, conditions not uncommon for solar microwave bursts, the gyrosynchroton spectrum can be suppressed for frequencies up to at least 10 GHz. Finally, I made use of the X-ray data from the *Yohkoh* spacecraft to learn more about this particular flare, and to check some of the results from the investigation of the radio spectrum. I found that the ambient density and electron spectral index inferred from the X-ray data matched those deduced from the microwave data.

Thesis-related Publications: ApJ, 400, 692 (Other chapters in preparation)

Meeting Summary

9th Cambridge Workshop on Cool Stars, Stellar Systems and the Sun

The 9th Cambridge Workshop on Cool Stars, Stellar Systems and the Sun was held in Florence, Italy, from October 3 to 6, 1995. It was attended by 280 scientists from 37 different countries, including a large participation from the U.S. (nearly 100 scientists), Italy, the UK (including 11 researchers from Northern Ireland), Germany, France, Spain, etc. There were also participants from the former Soviet Union, Japan, China, South America, South Africa, and Australia. In brief, it was the largest Cool Star Workshop ever held, showing that the decision to have the Cambridge Workshops once in a while outside of the US was probably a right one.

The main sessions of the Workshop (chaired respectively by Salvatore Serio, Carole Jordan, Jurgen Schmitt and Andrea Dupree) were devoted to:

- Recent advances in Solar Physics (with emphasis on results from Yohkoh)

- X-ray, EUV and UV coronal spectroscopy (with emphasis on results from ASCA, EUVE and HST)

- Cool Stars in clusters and star forming regions (including results from ROSAT and ground-based photometry and spectroscopy)

- Mass loss and winds from cool stars (where HST results played again a major role, in addition to solar results from Ulysses).

The opening session (chaired by the President of the IAU, Prof. Leodwijk Woltjer) offered an overview of the major accomplishments over the past two years in cool star research at optical, IR, radio, and XUV wavelengths (presented, respectively, by Mark Giampapa, Stephen White and Bernard Foing). In addition, a report was given (by Michel Grenon) on the results of Hipparchos relevant to cool star research. Since the Workshop had been dedicated to the memory of Olin C. Wilson, the opening talk (by Robert Noyes) summarised the scientific legacy of Olin Wilson and gave an inspiring view of the early days of cool star research.

Four very lively Discussion Sessions (chaired by John Carr, Thierry Montmerle, Jim Liebert and Marcello Rodonó) were held on the following topics:

- Near IR spectroscopy of cool stars

- Young stellar objects

- Very low-mass stars and brown dwarfs

- Active binaries

In the Session on very low-mass stars, Michel Mayor gave the announcement of the discovery of a Jupiter-mass companion to the solar-type star 51 Peg, which attracted much attention from the media.

More than 200 poster papers were presented at the Workshop, many of them reporting first-class results. Regrettably, there was not enough time to devote these posters all the attention they deserved.

A summary of the Workshop was presented at the end by Jeff Linsky.

The social program included a tour of the famous wine region of Chianti and a much appreciated closing dinner in a Renaissance "villa" on the hills overlooking Florence.

The Proceedings of the 9th Cambridge Workshop will be published by the Astronomical Society of the Pacific in their Conference Series and will be edited by Roberto Pallavicini and Andrea Dupree. They are expected to come out by middle 1996.

The next Cool Star Workshop (the 10th of the series) will go back to the origins and will be held in Cambridge, Massachusetts, from July 11 to 19, 1997, with Andrea Dupree as SOC chair and Lee Hartmann and John Stauffer as LOC chairs. Stay tuned for more info on CS10 on the WWW page http://cfa-www.harvard.edu/CS10/ .

Roberto Pallavicini (cs9@arcetri.astro.it)
Chairman of the Workshop, Osservatorio Astrofisico di Arcetri and Osservatorio Astronomico di Palermo

Meeting Summary

Stellar Surface Structure (IAU Symp. 176)

Indirect (Doppler) imaging techniques opened up a new era in stellar astronomy providing, for the first time, spatially resolved information about the surface structure of stars and their associated magnetic activity and chemical inhomogeneity. The large number of recent results, ground-based and space-based, and the lack of a dynamo theory valid for the stars *and* the Sun, result in an ever growing complexity of the interpretation of individual results. Because of this, the IAU Executive Committee at the General Assembly in 1994 decided that it is time to dedicate a whole IAU Symposium to this field.

This Symposium was held in Vienna at the University of Vienna in October 1995 as the 176th Symposium of the IAU and reviewed the current observational status with respect to disk-resolved observations of the stars and the Sun. A get-together of the "cool-star" and the "hot-star" community was also long overdue and highly desirable to gain insight on stellar surface structure throughout the Hertzsprung-Russell diagram. One logistic next step was to think about next-generation model atmospheres, e.g. including the outer atmosphere in case of late-type stars, or even taking into account their inhomogeneous geometry.

Over 100 poster papers covering the above topics are included in the booklet *Poster Proceedings: Stellar Surface Structure (IAU Symp. 176).* Please note that this *Poster Proceedings* is an important appendix to the Proceedings of the IAU-Symposium published through Kluwer Academic Press. The booklet is a special publication of the Univ. of Vienna, in color with a soft cover and A4 size, with 240 pages and a price of 350 ATS ($\approx$ 30 USD). Order your copy from: iau@astro.ast.univie.ac.at.

Klaus G. Strassmeier (iau@astro.ast.univie.ac.at)
Institut für Astronomie, Universität Wien, Türkenschanzstr, 17, A-1180 Wien, Austria

Announcement

NOAO Electronic Forum

The NOAO electronic forum inaugural issue is out, check out:

http://www.noao.edu/eforum/hottopic/topic.html

It gives a view of where NOAO will be headed in the next few years. Small telescopes and stellar research in general will likely be heavily impacted by this proposed plan for future NOAO operations.

There is a place to send comments directly to the observatory directors and users committee chairs, as well as to post public comments. We need comments! From NOAO telescope users!! Send yours in and get your friends to do it too!! Seriously, if there is any chance at all of influencing the future direction of NOAO, now is the opportunity. If you care at all, contribute your thoughts to the discussion.

Suzanne Hawley

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. The subject matter should pertain directly to cool stars (spectral types F,G,K, or M) or the sun. Both theoretical and observational abstracts are appropriate. Abstracts dealing with cool pre-main-sequence 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. 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, and (iv) *General Announcements* that provide or request research-related information. Requests for abstract templates and all other correspondence should be sent to the editor at coolnews@jila.colorado.edu .