COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Spectropolarimetric Observations of Active Stars

J.-F. Donati[1], M. Semel[2], B.D. Carter[3], D.E. Rees[4] and A.C. Cameron[5]

[1] Laboratoire d'Astrophysique, Observatoire Midi-Pyrénées, F–31400 Toulouse, France
[2] DASoP, Observatoire de Paris-Meudon, F-92195 Meudon-Cedex, France
[3] Faculty of Sciences, The Univ. of Southern Queensland, Toowoomba 4350, Australia
[4] CSIRO Division of Radiophysics, PO Box 76, Epping, NSW 2121, Australia
[5] School of Physics and Astronomy, Univ. of St Andrews, St Andrews, Scotland KY16 9SS

This paper reports the results of 5 yr (5 runs, 23 nights) of spectropolarimetric observations of active stars with the UCL Echelle Spectrograph of the Anglo-Australian Telescope. Two hundred and twenty five circularly (and four linearly) polarised spectra were recorded on 28 objects (21 active stars and 7 calibration standards) using the new technique of Zeeman-Doppler imaging.

To extract polarisation échelle spectra from raw frames, we developed a new dedicated automatic software package (called ESpRIT and utilizing optimal extraction techniques) whose detailed description is given in the paper. For each recorded spectrum, we extract "mean" polarised and unpolarised profiles using "Least-Squares Deconvolution", a technique similar to cross-correlation which can enhance enormously the sensitivity of Zeeman-Doppler imaging, by up to 7.5 mag in flux with respect to a single average line analysis or by 4.5 mag compared to the older technique of Donati et al. (1992a) in the particular case of a K1 star.

Magnetic field is detected unambiguously on 14 objects, namely the weak-line T Tauri star V410 Tau, the pre-main sequence binary HD 155555, the ZAMS stars AB Dor and LQ Hya, the dwarf flare star CC Eri, the RS CVn systems HR 1099, EI Eri, TY Pyx, CF Tuc, SZ Psc, II Peg, IM Peg and IL Hya, and the FK Com star YY Men. Marginal field detections are also obtained for the weak-line T Tauri star HD 283572 and the Herbig Ae star HD 104237. Except on HR 1099 and II Peg, our results represent the first *direct* field detections ever reported on these objects, and in particular the first *direct* field detection on as young a star as V410 Tau. Most of the magnetic signatures we detect on cool stars show several sign reversals throughout the line profile, witnessing that the parent field structure is rather complex and must feature (as expected) many small-scale magnetic regions of different polarities. For all stars on which Zeeman detections are recorded with sufficient accuracy (namely LQ Hya, CC Eri, HR 1099, EI Eri, II Peg, IL Hya and YY Men), differential Least-Squares Deconvolution from both the blue and red parts of the spectral domain indicates that the magnetic regions we detect are mostly 500 to 1,000 K cooler than, sometimes at the same temperature as, but never warmer than the surrounding photosphere.

Serendipitous results include the first detection (i) of small amplitude radial velocity variations (1.3 $\mathrm{km\,s^{-1}}$ peak to peak) of the Herbig Ae star HD 104237 with small enough a period (37.5 ± 1 min) that they must be due to stellar pulsations; and (ii) of the solar-like secondary component of the RS CVn system IL Hya.

Accepted by MNRAS

For preprints contact: donati@obs-mip.fr

For preprints via ftp or WWW: http://www.obs-mip.fr/omp/umr5572/people/donati

Discovery of the Lowest Mass Brown Dwarf in the Pleiades

M.R. Cossburn[1], S.T. Hodgkin[1], R.F. Jameson[1] and D.J. Pinfield[1]

[1] Department of Physics and Astronomy, Leicester University, University Road, Leicester, LE1 7RH, UK

We have imaged the Pleiades open cluster at I and Z in a search for low-mass stars and brown dwarfs. One very red object, which we have called PIZ 1, at I=19.64, I–Z=1.33 has been detected within an area of 100 arcmin^2. Follow up infrared photometry verifies that this object is extremely red with a K magnitude of 15.5 . We have also obtained a spectrum which exhibits the spectral features indicative of an extremely cool M dwarf. We estimate the effective temperature and mass of PIZ 1 to be 2300K and 0.048 $M_\odot$ respectively.

Accepted by MNRAS

For preprints contact: mrc@star.le.ac.uk

The Na I Resonance Lines as a Spectroscopic Test of Late-type Stellar Atmospheres

A. Tripicchio[1], G. Severino[1], E. Covino[1], L. Terranegra[1] and R. J. García López[2]

[1] Osservatorio Astronomico di Capodimonte, Via Moiariello 16, I - 80131 Naples, Italy
[2] Instituto de Astrofísica de Canarias, E-38200 La Laguna, Tenerife, Spain

We have tested current models for the atmospheres (including photosphere and low chromosphere) of late-type stars using the D resonance lines of neutral sodium as a diagnostic.

To this end, we have measured the equivalent widths of the D lines for a sample of 39 dwarf and 45 giant late-type stars observed with high spectral resolution. We constructed photospheric models over a grid in effective temperature and surface gravity spanning the spectral types F to M, and luminosity classes V and III of the sample stars. The model photospheres were extended into the chromosphere by assuming a suitable scaling from the Sun, and theoretical Na I D equivalent widths were computed over the grid of models including the deviations from local thermodynamic equilibrium.

By taking into account both the experimental errors and the possible variations of stellar parameters (effective temperature, surface gravity, sodium abundance and microturbulence), the comparison between observed and computed equivalent widths allows us to state that the model atmospheres we have used can reproduce the observations for the two luminosity classes and for all the spectral types except for the M-type stars. We have discussed the importance of line blanketing in the spectral analysis of these stars, but at present we cannot conclude that this effect would reduce the discrepancy.

Accepted by A&A

For preprints contact: tripicchio@na.astro.it

For preprints via ftp or WWW: http://www.na.astro.it/articoli/6127.ps.gz

The ROSAT All-sky Survey Catalogue of Optically Bright Late-type Giants and Supergiants

Matthias Hünsch[1,2], Jürgen H.M.M. Schmitt[1] and Wolfgang Voges[1]

[1] Max-Planck-Institut für extraterrestrische Physik, Giessenbachstrasse, D-85740 Garching, Germany
[2] Institut für Astronomie und Astrophysik, Olshausenstrasse 40, D-24118 Kiel, Germany

We present X-ray data for all late-type (A, F, G, K, M) giants and supergiants (luminosity classes I to III-IV) listed in the Bright Star Catalogue that have been detected in the ROSAT all-sky survey. Altogether, our catalogue contains 450 entries of X-ray emitting evolved late-type stars, which corresponds to an average detection rate of about 11.7 percent. The selection of the sample stars, the data analysis, the criteria for an accepted match between star and X-ray source, and the determination of X-ray fluxes are described.

Accepted by A&AS

For preprints contact: huensch@astrophysik.uni-kiel.de

Does Chromospheric Emission Mimic Polar Starspots in Doppler Images?

Y. C. Unruh[1] & A. Collier Cameron[1]

[1]School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Scotland KY16 9SS

We have used time-series spectra of the sodium doublet at 589.0 and 589.6 nm in AB Doradus to investigate the effects of a chromospheric temperature rise on Doppler images derived from strong lines whose cores are formed in the upper photosphere and lower chromosphere. On solar-type stars, the Na D lines probe a range of heights and tend to be much more sensitive to the chromospheric temperature structure than the weaker photospheric lines that are commonly used for Doppler imaging. Contrary to suggestions that polar spots may be an artefact due to chromospheric emission reversals, we find that the images obtained from the Na D lines show *less* high-latitude structure, and give more reliable light-curve predictions than, images derived previously from fits to several weaker photospheric lines.

Accepted by MNRAS

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Stellar Convection: Nonuniform Heating from Below

K. Stępień[1], M. Kiraga[1], K. Jahn[1] and H. J. Muthsam[2]

[1] Warsaw University Observatory, Al. Ujazdowskie 4, 00-478 Warszawa, Poland
[2] Institute of Mathematics, University of Vienna, Boltzmanngasse 5, A-1090 Vienna, Austria

An influence of a nonuniform energy flux leaving a rapidly rotating stellar core, on the subphotospheric convection zone was investigated. We used a two-dimensional, three-layer model with a convectively unstable zone sandwiched between two stable zones. Instead of a continuous energy flux distribution expected in real stars, a simplified model with a localized hot spot placed in the middle of the lower unstable zone was considered, to decrease a possible interference from the side boundaries on the pattern of motion. To further minimize the effect of side boundaries a large aspect ratio 1 : 8 was adopted for the unstable zone.

The results show that after a dynamical relaxation of the model a broad, stable updraft above the hot spot is formed. It induces large scale circulations involving horizontal motions from the spot axis near the top of the convection zone. The extend and kinetic energy of these motions increase with the energy flux excess brought by the spot. Four values of the flux excess were considered: 0.1, 0.3, 1.0 and 3.0. It is suggested that the nonuniform energy flux entering the convection zone may force a large scale flow of matter from the pole towards the equator in the surface layers of a rapidly rotating cool star. Horizontal distributions of radiative, convective, kinetic and total energy flux at different levels of the model with a hot spot are discussed.

Accepted by Acta Astronomica

For preprints contact: kst@astrouw.edu.pl

The Photosphere and Chromosphere of the RS CVn star, II Peg. II. A Multi-wavelength Campaign in August/September 1992

P.B. Byrne[1], H. Abdul Aziz[6] P.J. Amado[1], M.J. Arevalo[7], S. Avgoloupis[4], J.G. Doyle[1], M.T. Eibe[1], K.H. Elliott[5], R.D. Jeffries[5], A.C. Lanzafame[1], C. Lazaro[7], H.M. Murphy[1], J.E. Neff[3], K.P. Panov[8], L.M. Sarro[1], 2, J.H. Seiradakis[4], R.E. Spencer[6]

[1] Armagh Observatory, Armagh BT61 9DG, N. Ireland
[2]LAEFF, Vilspa, Madrid, Spain
[3]Department of Astronomy, Pennsylvania State University, 525 Davey Laboratory, University Park, PA 16802, USA
[4]University of Thessaloniki, Department of Physics, Section of Astrophysics, Astronomy and Mechanics, GR-54006, Greece
[5]School of Physics and Space Research, University of Birmingham, Birmingham B15 2TT, England
[6]University of Manchester, Jodrell Bank, Macclesfield, SK11 9DL, England
[7]Instituto de Astrofisica de Canarias, via Lactea, E-38200 La Laguna, Tenerife, Canary Islands, Spain
[8]National Astronomical Observatory, Bulgarian Academy of Sciences, 72 Trakya Blvd., Sofia 1754, Bulgaria

We describe multi-wavelength, simultaneous observations of the RS CVn star, II Pegasi, most of which were obtained during the first three weeks of September 1992. These observations were made using optical and infra-red broad-band photometry, ultraviolet and optical spectroscopy and microwave monitoring. We have detected photospheric spots and chromospheric flares, as well as deriving a description of mean conditions in the quiet chromosphere. One of the flares, observed in optical photometry and ultraviolet spectroscopy is one of the most energetic ever observed on this star. We demonstrate that in its "quiescent" state II Peg is continually variable in most of its chromospheric emissions, as well as in its coronal output.

Accepted by A&AS

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A SAX/LECS X-ray Observation of the Active Binary Capella

F. Favata[1], R. Mewe[2], N. S. Brickhouse[3], R. Pallavicini[4], G. Micela[4] and A. K. Dupree[3]

[1] Astrophysics Division – Space Science Department of ESA, ESTEC, Postbus 299, NL-2200 AG Noordwijk, The Netherlands
[2] SRON Laboratory for Space Research, Sorbonnelaan 2, NL-3584, Utrecht, The Netherlands
[3] Harvard-Smithsonian Center for Astrophysics, 60 Garden St., 02138 Cambridge, Mass., USA
[4] Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy

We present a SAX/LECS X-ray observation of the active binary Capella, the first coronal source observed in the SAX Guest Investigator program. The analysis of this observation, performed using the MEKAL plasma emission code, shows that the LECS spectrum is well fit by a two-component optically-thin plasma model. A differential emission measure (DEM) obtained by direct inversion of the X-ray spectrum shows no additional features in addition to the double-peaked structure implied by the direct two-temperature analysis. Such a simple temperature stratification is however not compatible with the EUVE emission from the same object, which is well represented by a more complex DEM, with a power-law-like tail toward the low temperatures. At the same time, the EUVE-derived DEM predicts well the softer part of the Capella LECS spectrum, but it fails to correctly reproduce the higher energy part of the Capella LECS spectrum. Possible causes for this discrepancy are discussed. The coronal metallicity derived from the SAX observation is compatible both with the EUVE-derived metallicity as well as with the photospheric metallicity of Capella, thus showing no evidence for coronal under-abundances.

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For preprints contact: ffavata@astro.estec.esa.nl

A BeppoSAX Observation of the Coronal X-ray Emission of the Active Binary VY Ari

F. Favata[1], T. Mineo[2], A. N. Parmar[1] and G. Cusumano[2]

[1] Astrophysics Division – Space Science Department of ESA, ESTEC, Postbus 299, NL-2200 AG Noordwijk, The Netherlands
[2] IFCAI/CNR, Via U. La Malfa 153, I-90146 Palermo, Italy

We present a study of the X-ray coronal emission from the active binary VY Ari, using data from both the Low Energy Concentrator Spectrometer (LECS) and the Medium Energy Concentrator Spectrometer (MECS) instruments on-board the X-ray satellite BeppoSAX. Using these instruments, the X-ray spectrum of VY Ari can be studied across two full decades of energy, from 0.1 to 10 keV. The spectrum is well fit, across the whole spectral range, with an optically thin plasma MEKAL model with two discrete temperature components, and with an inferred coronal abundance [Fe/H] $\simeq -0.4$, corresponding to the average typical value of the photospheric abundance in RS CVn-type binaries.

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For preprints contact: ffavata@astro.estec.esa.nl

Solar Abstracts

Turbulent Coronal Heating and the Distribution of Nanoflares

Pablo Dmitruk[1,2] and Daniel O. Gómez[1,3,4]

[1] Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria, 1428 Buenos Aires, Argentina
[2] Fellow of Universidad de Buenos Aires
[3] Also at the Instituto de Astronomía y Física del Espacio, Buenos Aires, Argentina
[4] Member of the Carrera del Investigador, CONICET, Argentina

We perform direct numerical simulations of an externally driven two-dimensional magnetohydrodynamic system over extended periods of time to simulate the dynamics of a transverse section of a solar coronal loop. A stationary and large-scale magnetic forcing was imposed, to model the photospheric motions at the magnetic loop footpoints. A turbulent stationary regime is reached, which corresponds to energy dissipation rates consistent with the heating requirements of coronal loops.

The temporal behavior of quantities such as the energy dissipation rate show clear indications of intermittency, which are exclusively due to the strong nonlinearity of the system. We tentatively associate these impulsive events of magnetic energy dissipation (from 5×10^{24} erg to 10^{26} erg) to the so-called nanoflares. A statistical analysis of these events yields a power law distribution as a function of their energies with a negative slope of 1.5, which is consistent with those obtained for flare energy distributions reported from X-ray observations.

Accepted by ApJL

For preprints contact: dmitruk@df.uba.ar

For preprints via ftp or WWW: http://www.iafe.uba.ar

Hamilton Echelle Spectroscopy of the 6 March 1993 Solar Flare

C.M. Johns–Krull[1], S.L. Hawley[2], G. Basri[3] and J.A. Valenti[4]

[1] McDonald Observatory, The University of Texas at Austin, Austin, TX 78712 USA
[2] Physics and Astronomy Department, Michigan State University, East Lansing, MI 48824 USA
[3] Astronomy Department, University of California, Berkeley, CA 94720 USA
[4] JILA, Campus Box 440, University of Colorado, Boulder, CO 80309 USA

We report on a successful program designed to use the Hamilton echelle spectrograph and the Coudé Auxiliary Telescope at Lick Observatory to take spectra of solar flares. Our observations consist of high resolution ($\lambda/\delta\lambda \sim 48000$) spectra covering the entire optical region from approximately 3800 to 9000 Å in each exposure. These are the first time resolved, high resolution optical spectra of this type obtained for a solar flare.

On 6 March 1993 we observed a relatively large (GOES class M7.7) solar flare event. Our sequence of observations begins before flare maximum, and continues for more than an hour. We present our high signal-to-noise spectra and compare them with similar stellar flare observations. We find that the hydrogen emitting layers differ markedly between flares on the Sun and on dMe stars, though the total energy emitted in various emission lines can be rather similar. We also find that the amount of energy released in the optical emission lines is similar to that emitted in soft X-rays. We find evidence for Stark broadening in the Balmer lines at lower series members than reported in earlier studies. This appears to be due to the optical depth in the Balmer lines being lower than in previously reported flares. Early in the flare, the Hα and Hβ line profiles appear to be asymmetric as a result of *absorption* by chromospheric material expanding upward into the corona. We also examine solar flare model atmospheres synthesized with the NLTE code MULTI and find that our observations can be generally understood in terms of equilibrium models of electron beam and X-ray heated chromospheres in equilibrium with coronal loops where the pressure is rather high; however, there remain marked differences between the theoretical predictions and our observations, implying that substantial refinement of the models is in order. Several photospheric lines show flare enhancements as well. The temporal behavior of these line enhancements is identical to that of the chromospheric lines, but there is no indication that significant flare heating penetrates to continuum formation depths.

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Systematic Redshifts in the Quiet Sun Transition Region and Corona Observed with SUMER on SOHO

P. Brekke[1], D. M. Hassler[2] and K. Wilhelm[3]

[1] Institute of Theoretical Astrophysics, University of Oslo, Oslo, Norway
[2] High Altitude Observatory, National Center for Atmospheric Research, Boulder, Colorado, USA
[3] Max-Planck-Institut für Aeronomie, D-37189 Katlenburg-Lindau, Germany

New observations of systematic redshifts of transition region and coronal lines obtained with SUMER (Solar Ultraviolet Measurements of Emitted Radiation) on SOHO (the Solar and Heliospheric Observatory) are presented. With the extensive wavelength coverage of SUMER it is possible to extend the measurements of the redshifts to much higher temperatures compared to previous instruments. Our results indicate that the redshifts are present even in the upper transition region (e.g. O V, S V, and S VI). Even O VI, Ne VIII and Mg X show systematic redshifts in the quiet Sun spectra. The lack of systematic blue shifts in lines like Mg X may rise the question: Where does the solar wind come from? Future work includes the comparison of the systematic redshifts in different solar features, such as plages, coronal holes and a detailed analysis of the center-to-limb variations of the shifts.

Accepted by Solar Physics

For preprints contact: paalb@astro.uio.no

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Randomly Sampling the Chromospheric Peak Power Distribution

J.G. Doyle[1], G.H.J. van den Oord[2] & E. O'Shea[1]

[1] Armagh Observatory, Armagh BT61 9DG, N. Ireland
[2] Sterrekundig Instituut, P.O. Box 80.000, 3508 TA Utrecht, The Netherlands

We have analyzed the UV continuum light curves of 2535 pixels obtained during fifteen separate observations of active regions with the Ultraviolet Spectrometer and Polarimeter (UVSP) on board the solar maximum mission in 1989. Specifically we have looked for periodicities. In the power spectra of 738 light curves (i.e., 29%), evidence was found for periodicities at multiple frequencies. For each power spectrum, containing significant power, we determined the frequency at which the maximum power is found. The distribution $N(\nu)$, which describes the number of pixels having maximum power at frequency ν, is strongly concentrated in the 2 – 5 mHz band with a distinct maximum at 3 – 3.5 mHz. No pixels had their maximum power above 10 mHz and only a few had their maximum power in the 5 – 10 mHz range. The oscillations in the 2 – 5 mHz range are probably related to evanescent acoustic waves driven by the photospheric five minute oscillations. In the 2 – 5 mHz band, the distribution $N(\nu)$ resembles very much the power spectra as have been observed near the temperature minimum. This suggests that the photospheric power distribution

can be interpreted as a probability distribution for finding a given frequency in the UV continuum light curves. In the 2 – 5 mHz band the spread of the maximum powers and the spread of the count rates, at any frequency, is much larger than above 5 mHz where both are relatively constant. No clear correlation is found between the maximum power and the count rate in a pixel. Furthermore, no evidence is found for emission from the shocks which have recently been invoked to explain the formation of Ca II grains. Whether this is due to temperature effects is unclear. Our general procedure adopted to estimate the confidence level in the power spectrum of a light curve containing photon noise can be equally applied to SUMER and CDS data from SOHO.

Accepted by A&A

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

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Compressible Plume Dynamics and Stability

Mark Peter Rast[1]

[1]JILA, Campus Box 440, Univ. of Colorado, Boulder, CO 80309 USA

This paper presents a numerical study of the dynamics and stability of two-dimensional thermal plumes in a significantly stratified layer. Motivated by stellar envelope convection in which radiative cooling at the stars photosphere drives vigorous downflows, we examine cool plumes descending through an adiabatically stratified layer of increasing density with depth. Such flows are inaccessible by laboratory experiments, yet are important to the understanding of heat and momentum transport, magnetic field generation, and acoustic excitation in stars like the Sun. We find that the structure of thermal plumes in a stratified compressible medium is significantly different from that in an incompressible one, with pressure perturbations playing an important dynamical role. Additionally, we find that the plumes are subject to vigorous secondary instabilities even in a quiescent background medium, resulting in detrainment of fluid from the plume region. Thus simplified plume models assuming hydrostatic pressure distribution and velocity proportional entrainment may be inappropriate in this context.

Submitted to Journal of Fluid Mechanics

For preprints contact: mprast@solarz.colorado.edu

Dynamics of the Solar Granulation – IV Granular Shear Flow

A. Nesis[1], **R. Hammer**[1], **A. Hanslmeier**[2], **H. Schleicher**[1], **M. Sigwarth**[1], **and J. Staiger**[1]

[1] Kiepenheuer-Institut für Sonnenphysik, Schöneckstr. 6, D-79104 Freiburg, F.R.G.

[2] Institut für Astronomie, Universitätsplatz 5, A-8010 Graz, Austria

Strong velocity gradients at granular borders appear to be the source of unresolved velocity fluctuations detectable as line broadening variations of magnetically and thermally insensitive absorption lines. Based on spectrograms of high spatial and spectral resolution taken with the German Vacuum Tower Telescope (VTT) in Izaña (Tenerife) we study the strong velocity gradients and the unresolved velocity field as well as their mutual interaction. We also investigate the variation of these quantities with the height in the photosphere, for both a regular and an exploding granule. By means of a coherence analysis we study, furthermore, the extension of the convective and turbulent fluctuation field of the granulation layers into the overlying overshoot layers as a function of the wavenumber. The results of the coherence analysis are consistent with, and complementary to, those obtained from the investigation of regular and exploding granules.

The small and large scales of the convective and unresolved velocity field behave clearly different as far as their penetration into the overlying photospheric layers is concerned. One pressure scale height above the continuum we find an unresolved velocity field that does not show any resemblance to the same velocity field at the continuum level. We find that the symmetry behavior of the unresolved velocity field with respect to the granular flow varies with the height in the photosphere.

The unresolved velocity field could be of oscillatory, convective, or turbulent character. However, the fact that the unresolved velocity field is more prominent at the granular border, which is also the location of strong shear flow, favors its turbulent character. In this sense the granules can be seen as quasi-laminar convective flows emerging in the turbulent field of the overshoot layers.

Accepted by A&A

For preprints contact: nesis@kis.uni-freiburg.de

For preprints via ftp or WWW: http://www.kis.uni-freiburg.de/~nesis/Dynamics_IV.ps.gz

On the Role of the Solar Corona and Transition Region in the Excitation of the Spectrum of Neutral Helium

Vincenzo Andretta[1] **and Harrison P. Jones**[2]

[1]NASA/Goddard Space Flight Center, Laboratory for Astronomy and Solar Physics – Code 682 – Greenbelt, MD 20771 – USA
[2]NASA/Goddard Space Flight Center, Laboratory for Astronomy and Solar Physics – Southwest Solar Station – c/o National Solar Observatory – P.O. Box 26732 – Tucson, AZ 85726-6732 – USA

We investigate the formation of the spectrum of neutral helium in the solar atmosphere by solving the corresponding non-LTE problem in an extended grid of model atmospheres. From the results we infer several general properties and scaling-laws that can be used to discriminate the different proposed formation mechanisms. Some of the scaling laws have also been tested in a comparison with previous calculations made with different assumptions.

In our models, the excitation of the spectrum by direct photoionization by EUV radiation shortward of 504 Å followed by recombinations (PR mechanism), seems to be capable of influencing significantly the resonance continuum and the subordinate lines, even in the presence of other (collisional) excitation mechanisms. While this influence is almost unavoidable in most atmospheric features, it is hardly justifiable as the only possible contribution. Moreover, the resonance lines seem inclined to respond much more effectively to the conditions of the lower transition region, even in the presence of a significant coronal EUV illumination. With the help of the detailed non-LTE calculations and of the derived scaling laws, we explore the interplay of the possible formation mechanisms and their effect on the individual spectral features.

Accepted by ApJ

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Plasma Heating by Alfvén Wave Filamentation : A Relevant Mechanism in the Solar Corona and the Interstellar Medium

Stéphanie Champeaux[1], **Adriana Gazol**[1], **Thierry Passot**[1] **and Pierre-Louis Sulem**[1]

[1]CNRS, UMR 6529, Observatoire de la Côte d'Azur, B.P. 4229, 06304, Nice Cedex 4, France

A mechanism for small-scale generation in magnetically dominated homogeneous space plasmas is proposed, resulting from transverse collapse (filamentation) of weakly nonlinear circularly polarized Alfvén waves. It is argued that waves whose frequencies exceed a magnitude of about 10 Hz, can significantly contribute to the heating of open coronal holes and to the acceleration of the fast solar wind. In coronal loops, this frequency bound reduces to 1 Hz. The importance of Alfvén wave filamentation is also demonstrated in the warm ionized phase of the interstellar medium.

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For preprints contact: passot@obs-nice.fr

Announcements

COOL STARS 10 ABSTRACTS NOW ON-LINE

The entire Abstract Book for the 10th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun is now on the WWW. The abstracts are in PostScript format. The base URL is

http://cfa-www.harvard.edu/cs10/Abstracts/

and one can search by (co-)author, object, and topic.

Submitted by: Bob Donahue (CS10 Co-editor)

Editor's Note: The CS10 home page is on: http://cfa-www.harvard.edu/CS10/

Announcements

REVIEW ARTICLE ON BETELGEUSE

Dear Colleagues:

I am writing a general review article on Betelgeuse for "Astronomy and Geophysics" - the journal that has replaced the Royal Astronomical Society's Quartery Journal. I would be VERY grateful for any recent data, preprints, reprints, opinion etc that you have on any aspect of Betelgeuse, its evolution, or similar stars. I have to meet a press date for the article of beginning of October. It may help to remind the astronomical world that stars are important as well as galaxies and cosmology! In particular, I would also love to have some nice colour illustrations - possibly for the cover of the journal. Does anyone have anything nice? Of course, any contributions would be fully acknowledged.

If you can help, please send to any of:

e-mail: mge@astro.cf.ac.uk

FAX: 44 - 1222 874056

Post: Dr Mike Edmunds, Department of Physics and Astronomy, PO Box 913 Cardiff CF2 3YB UK

or let me know where I can browse your WEB address.

Very Many Thanks, Mike E.

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, (iv) reviews of *New Books*, and (v) *General Announcements* that provide or request research-related information. Please send all correspondence to the editor at coolnews@jila.colorado.edu. Abstract templates and back issues can be obtained from the COOLNEWS Web-page at

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