COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Time Scales of Li Evolution: A Homogeneous Analysis of Open Clusters from ZAMS to Late-MS

P. Sestito[1], **and S. Randich**[2]

[1] INAF/Osservatorio Astronomico di Bologna, Via C. Ranzani 1, I-40127 Bologna, Italy
[2] INAF/Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy

We have performed a new and homogeneous analysis of all the Li data available in the literature for main sequence stars (spectral-types from late F to K) in open clusters. In the present paper we focus on a detailed investigation of MS Li depletion and its time scales for stars in the 6350–5500 K effective temperature range. For the first time, we were able to constrain the age at which non-standard mixing processes, driving MS Li depletion, appear. We have also shown that MS Li depletion is not a continuous process and cannot be simply described by a $t^{-\alpha}$ law. We confirm that depletion becomes ineffective beyond an age of 1–2 Gyr for the majority of the stars, leading to a Li plateau at old ages. We compared the empirical scenario of Li as a function of age with the predictions of three non-standard models. We found that models including only gravity waves as main mixing process are not able to fit the Li vs. age pattern and thus this kind of mixing can be excluded as the predominant mechanism responsible for Li depletion. On the other hand, models including slow mixing induced by rotation and angular momentum loss, and in particular those including also diffusive processes not related to rotation, can explain to some extent the empirical evidence. However, none of the currently proposed models can fit the plateau at old ages.

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For preprints contact: paola.sestito@bo.astro.it

Photometric Observations from Theoretical Flip-flop Models

H. Korhonen[1] **and D. Elstner**[1]

[1]Astrophysikalisches Institut Potsdam, An der Sternwarte 16, D-14882 Potsdam, Germany

Some active stars show a so-called flip-flop phenomenon in which the main spot activity periodically switches between two active longitudes that are 180 degrees apart. In this paper we study the flip-flop phenomenon by converting results from dynamo calculations into long-term synthetic photometric observations, which are then compared to the real stellar observations. We show that similar activity patterns as obtained from flip-flop dynamo calculations, can also be seen in the observations. The long-term light-curve behaviour seen in the synthesised data can be used for finding new stars exhibiting the flip-flop phenomenon.

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For preprints contact: hkorhonen@aip.de

For preprints via ftp or WWW: http://www.aip.de/∼hkorhone/publications.html

A New Version of Reimers' law of Mass Loss Based on a Physical Approach

K.-P. Schröder[1] and M. Cuntz[2]

[1] Astronomy Centre, University of Sussex, Brighton, BN1 9QH, England
[2] Department of Physics, University of Texas at Arlington, Box 19059, Arlington, TX 76019, USA

We present a new semi-empirical relation for the mass loss of cool stellar winds, which so far has frequently been described by "Reimers' law". Originally, this relation was based solely on dimensional scaling arguments without any physical interpretation. In our approach, the wind is assumed to result from the spill-over of the extended chromosphere, possibly associated with the action of waves, especially Alfvén waves, which are used as guidance in the derivation of the new formula. We obtain a relation akin to the original Reimers law, but which includes two new factors. They reflect how the chromospheric height depends on gravity and how the mechanical energy flux depends, mainly, on effective temperature. The new relation is tested and sensitively calibrated by modelling the blue end of the Horizontal Branch of globular clusters. The most significant difference from mass loss rates predicted by the Reimers relation is an increase by up to a factor of 3 for luminous late-type (super-)giants, in good agreement with observations.

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For preprints contact: kps@central.susx.ac.uk

X-rays from α Centauri - The Darkening of the Solar Twin

J. Robrade[1], J.H.M.M. Schmitt[1] and F. Favata[2]

[1] Hamburger Sternwarte, Universität Hamburg, Gojenbergsweg 112, D-21029 Hamburg, Germany
[2] Astrophysics Division – Research and Science Support Department of ESA, ESTEC, Postbus 299, NL-2200 AG Noordwijk, The Netherlands

We present first results from five XMM-Newton observations of the binary system α Centauri, which has been observed in snapshot like exposures of roughly two hours each during the last two years. In all our observations the X-ray emission of the system is dominated by α Cen B, a K1 star. The derived light curves of the individual components reveal variability on short timescales and a flare was discovered on α Cen B during one observation. A PSF fitting algorithm is applied to the event distribution to determine the brightness of each component during the observations. We perform a spectral analysis with multi-temperature models to calculate the X-ray luminosities. We investigate long term variability and possible activity cycles of both stars and find the optically brighter component α Cen A, a G2 star very similar to our Sun, to have fainted in X-rays by at least an order of magnitude during the observation program, a behaviour never observed before on α Cen A, but rather similar to the X-ray behaviour observed with XMM-Newton on HD 81809. We also compare our data with earlier spatially resolved observations performed over the last 25 years.

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

For preprints via WWW: http://www.hs.uni-hamburg.de/DE/Ins/Per/Robrade/index.html

Evidence for Granulation and Oscillations in Procyon from Photometry with the WIRE Satellite

H. Bruntt[1], H. Kjeldsen[2], D.L. Buzasi[3] and T.R. Bedding[4]

[1] Niels Bohr Institute, University of Copenhagen, Juliane Maries Vej 30, DK-2100 Copenhagen Ø, Denmark
[2] Department of Physics and Astronomy, University of Aarhus, Bygn. 520, DK-8000 Aarhus C., Denmark
[3] US Air Force Academy, Department of Physics, CO, USA
[4] School of Physics, University of Sydney, Australia

We report evidence for the granulation signal in the star Procyon A, based on two photometric time series from the star tracker on the WIRE satellite. The power spectra show evidence of excess power around 1 mHz, consistent with the detection of p-modes reported from radial velocity measurements. We see a significant increase in the noise level below 3 mHz, which we interpret as the granulation signal. We have made a large set of numerical simulations to constrain the amplitude and timescale of the granulation signal and the amplitude of the oscillations. We find that the timescale for granulation is $\Gamma_{\rm gran} = 750 \pm 200\,$s, the granulation amplitude is 1.8 ± 0.3 times solar, and the amplitude of the p-modes is $8.5 \pm 2\,$ppm. We found the distribution of peak heights in the observed power spectra to be consistent with that expected from p-mode oscillations. However, the quality of the data is not sufficient to measure the large separation or detect a comb-like structure, as seen in the p-modes of the Sun. Comparison with the recent negative result from the MOST satellite reveal that the MOST data must have an additional noise source that prevented the detection of oscillations.

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For preprints contact: bruntt@phys.au.dk

Solar Abstracts

Confined and Ejective Eruptions of Kink-unstable Flux Ropes

Tibor Török[1] and Bernhard Kliem[2]

[1] Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey RH5 6NT, UK
[2] Astrophysical Institute Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany

The ideal helical kink instability of a force-free coronal magnetic flux rope, anchored in the photosphere, is studied as a model for solar eruptions. Using the flux rope model of Titov & Démoulin (1999) as the initial condition in MHD simulations, both the development of helical shape and the rise profile of a confined (or failed) filament eruption (on 2002 May 27) are reproduced in excellent agreement with the observations. By modifying the model such that the magnetic field decreases more rapidly with height above the photosphere, a full (or ejective) eruption of the flux rope is obtained in excellent agreement with the developing helical shape and the exponential-to-linear rise profile of a fast coronal mass ejection (CME) (on 2001 May 15). This confirms that the helical kink instability of a twisted magnetic flux rope can be the mechanism of the initiation and the initial driver of solar eruptions. The agreement of the simulations with properties that are characteristic of many eruptions suggests that they are often triggered by the kink instability. The decrease of the overlying field with height is a main factor in deciding whether the instability leads to a confined event or to a CME.

Accepted by ApJL

For preprints contact: tt@mssl.ucl.ac.uk

For preprints via ftp or WWW: `http://www.mssl.ucl.ac.uk/~tt/publ/kink2emulateapj.pdf`

Eruption of a Kink-unstable Filament in NOAA Active Region 10696

David R. Williams[1], Tibor Török[1], Pascal Démoulin[2], Lidia van Driel-Gesztelyi[1,2,3], and Bernhard Kliem[4]

[1] Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Dorking, Surrey RH5 6NT, UK
[2] Observatoire de Paris, 92195 Meudon Cedex, France
[3] Konkoly Obszervatórium, Pf. 67, 1525 Budapest, Hungary
[4] Astrophysical Institute Potsdam, 14482 Potsdam, Germany

We present rapid-cadence *Transition Region and Coronal Explorer (TRACE)* observations that show evidence of a filament eruption from NOAA active region 10696, accompanied by an X2.5 flare, on 2004 November 10. The eruptive filament, which manifests as a fast coronal mass ejection some minutes later, rises as a kinking structure with an apparently exponential growth of height within *TRACE*'s field of view. We compare the characteristics of this filament eruption with MHD numerical simulations of a kink-unstable magnetic flux rope, finding excellent qualitative agreement. We suggest that while tether weakening by breakout-like quadrupolar reconnection may be the release mechanism for the previously confined flux rope, the driver of the expansion is most likely the MHD helical kink instability.

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For preprints contact: drw@mssl.ucl.ac.uk

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AFS Dynamics in a Short-lived Active Region

F. Zuccarello[1], V. Battiato[1], L. Contarino[2] , P. Romano[1] , D. Spadaro[2] and L. Vlahos[3]

[1] Dipartimento di Fisica e Astronomia - Sezione Astrofisica, Università di Catania, Via S. Sofia 78, 95125 Catania, Italy
[2] INAF-Osservatorio Astrofisico di Catania, Via S. Sofia 78, 95125 Catania, Italy
[3] Department of Physics, University of Thessaloniki, 54124 Thessaloniki, Greece

In the framework of the study on active region emergence, we report the results obtained from the analysis of the short-lived (7 days) active region NOAA 10407. The data used were acquired during an observational campaign carried out with the THEMIS telescope in IPM mode in July 2003, coordinated with other ground- and space-based instruments (INAF-OACT, DOT, BBSO, MDI/SOHO, EIT/SOHO, TRACE). We determined the morphological and magnetic evolution of NOAA 10407, as well as the velocity fields associated with its magnetic structures. Within the limits imposed by the spatial and temporal resolution of the images analyzed, the first evidence of the active region formation is initially observed in the transition region and lower corona, and later on (i.e. after about 7 hours) in the inner layers, as found in a previous analysis concerning a long-lived, recurrent active region. The results also indicate that the AFS formed in the active region shows typical upward motion at the AFS's tops and downward motion at the footpoints. The velocity values relevant to the upward motions decrease over the evolution of the region, similarly to the case of the recurrent active region, while we notice an increasing trend in the downflow velocity during the early phases of the time interval analyzed by THEMIS. On the other hand, the AFS preceding legs show a higher downflow than the following ones, a result in contrast with that found in the long-lived active region. The chromospheric area overhanging the sunspot umbra shows an upward motion of ~ 2 km s^{-1}, while that above the pores shows a downward motion of ~ 4 km s^{-1}.

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For preprints contact: fzu@ct.astro.it

Plasma Diagnostics of Active Region Evolution and Implications for Coronal Heating

R. O. Milligan[1,3], P. T. Gallagher[2,3,4], M. Mathioudakis[1], F. P. Keenan[1], and D. S. Bloomfield[1]

[1] Department of Physics and Astronomy, Queen's University Belfast, University Road, Belfast, BT7 1NN, Northern Ireland

[2] Department of Experimental Physics, University College Dublin, Belfield, Dublin 4, Ireland

[3] Laboratory for Astronomy and Solar Physics, NASA Goddard Space Flight Centre, Greenbelt, MD 20771, U.S.A.

[4] L-3 Communications GSI

A detailed study is presented of the decaying solar active region NOAA 10103 observed with the Coronal Diagnostic Spectrometer (CDS), the Michelson Doppler Imager (MDI) and the Extreme-ultraviolet Imaging Telescope (EIT) onboard the *Solar and Heliospheric Observatory (SOHO)*. Electron density maps formed using Si x(356.03 Å/347.41 Å) show that the density varies from $\sim 10^{10}$ cm^{-3} in the active region core, to $\sim 7\times10^{8}$ cm^{-3} at the region boundaries. Over the five days of observations, the average electron density fell by ∼30 per cent. Temperature maps formed using Fe xvi(335.41 Å)/Fe xiv (334.18 Å) show electron temperatures of $\sim 2.34\times10^{6}$ K in the active region core, and $\sim 2.10\times10^{6}$ K at the region boundaries. Similarly to the electron density, there was a small decrease in the average electron temperature over the five day period. The radiative, conductive, and mass flow losses were calculated and used to determine the resultant heating rate (P_H). Radiative losses were found to dominate the active region cooling process. As the region decayed, the heating rate decreased by almost a factor of five between the first and last day of observations. The heating rate was then compared to the total unsigned magnetic flux ($\Phi_{tot} = \int dA|B_z|$), yielding a power-law of the form $P_H \sim \Phi_{tot}^{0.81\pm0.32}$. This result suggests that waves rather than nanoflares may be the dominant heating mechanism in this active region.

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For preprints contact: r.milligan@qub.ac.uk

Dynamics of Solar Mesogranulation

Martin Leitzinger[1], Peter N. Brandt[2], Arnold Hanslmeier [1], Werner Pötzi[1] and Johann Hirzberger[1]

[1] Institut für Physik, IGAM, Karl-Franzens Universität Graz, Universitätsplatz 5, A-8010 Graz, Austria

[2] Kiepenheuer-Institut für Sonnenphysik, Schöneckstr. 6, D-79104 Freiburg, Germany

Using a 45.5-h time series of photospheric flow fields generated from a set of high-resolution continuum images (SOHO/MDI) we analyze the dynamics of solar mesogranule features. The series was prepared applying a local correlation tracking algorithm with a 4.8" FWHM window. By computing 1-h running means in time steps of 10 minutes we generate 267 averaged divergence maps that are segmented to obtain binary maps. A tracking algorithm determines lifetimes and barycenter coordinates of regions of positive divergence defined as mesogranules (MGs). If we analyze features of lifetimes ≥ 1 h and of areas ≥ 5 Mm^2 we find a mean drift velocity of 304 ms^{-1} (with $\pm 1\sigma$ variation of 180 ms^{-1}), a mean travel distance of 2.5 ±1.8 Mm, a mean lifetime of 2.6 ±1.8 h, and a $1/e$ decay time of 1.6 h for a total of 2022 MGs. The advective motion of MGs within supergranules is seen for 50 to 70 % of the long-lived ($\geq$ 4 h) MGs while the short-lived ones move irregularly. If only the long-lived MGs are further analyzed the drift velocities reduce to 207 ms^{-1} and the travel distances increase to 4.1 Mm on average, which is an appreciable fraction of the supergranular radius. The results are largely independent of the divergence segmentation level.

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For preprints contact: martin.leitzinger@aon.at

Ph.D. Thesis Abstract

Magnetic Flux Transport on the Sun

Ingo Baumann

Thesis work conducted at: Max-Planck-Institut fuer Sonnensystemforschung, Katlenburg-Lindau, Germany

Current address: MPS, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany

E-mail: baumann@mps.mpg.de

Ph.D dissertation directed by: Sami K. Solanki

Ph.D degree awarded: March 2005

Solar activity phenomena are based on magnetic fields. Magnetic field is generated by a dynamo in the solar interior and emerges as bipolar magnetic structures on the solar surface. The photospheric magnetic flux is redistributed by turbulent diffusion, differential rotation and meridional flow.

In this thesis we investigate the evolution of the photospheric large-scale magnetic field using a numerical code. We made an extensive study of flux transport model and solar cycle parameters. We present an extension of existing flux transport models by an additional decay term which is needed in order to correctly describe the observed magnetic field evolution. We use the RGO sunspot database in order to simulate the historic photospheric magnetic field and, combined with source surface models, the historic open magnetic flux.

- A numerical code has been developed in order to simulate the time evolution of the global magnetic field under the influence of supergranular diffusion, differential rotation and a meridional flow.
- An extensive parameter study has been done in order to investigate the influence of a variety of solar cycle parameters on the solar magnetic field with focus on the Sun's total surface field and the polar field.
- The existing flux transport model has been extended by a term parametrising radial decay processes. The necessity of this extension follows from comparing numerical simulations with observations. The extended model improves especially the modelling of long-term trends, like the polar field evolution.
- The Sun's surface magnetic field has been simulated with the extended surface flux transport model using the RGO/USAF sunspot data. The simulation is in good agreement with the observed solar magnetic field.
- A source surface model is used in order to calculate the Sun's open magnetic flux. Attempts to model the historic IMF record on the basis of the Greenwich sunspot database are unsatisfying because of insufficient open flux resulting from the low latitudes during activity maximum. Adding the open flux contribution of ephemeral regions improves the results.
- The size distribution of sunspot groups has been investigated. Both, the maximum areas and the instantaneous areas are found to be log-normally distributed. This result is confirmed by a simple decay model.

Thesis-related Publications: A&A 426, 1075

For preprints contact: baumann@mps.mpg.de

For preprints via ftp or WWW: http://www.mps.mpg.de/homes/baumann/papers/thesis_Baumann.pdf

Upcoming Meeting

Why Galaxies Care About AGB Stars: Their Importance as Actors and Probes

Vienna, Austria

7 – 11 August 2006

Stars are conspicuous components of galaxies, and the sites of the creation of most chemical elements. Due to their brightness and their production of heavy elements, stars on the Asymptotic Giant Branch (AGB) play an important role for understanding stellar and galactic evolution. This conference aims to build a bridge between AGB research and its application to the modelling of stellar populations and the chemical evolution of galaxies. Current developments and challenges on both sides will be discussed to reach an understanding of possibilities, limitations, and needs in both areas, and hence to improve our knowledge about the role of AGB stars in the context of galaxies.

The meeting will address the following three major topics:

Nucleosynthesis, mixing, and abundance determination of AGB stars Mass loss from AGB stars AGB stars and galactic evolution

The conference will be hosted by the Austrian Society for Astronomy and Astrophysics and the Department of Astronomy at the University of Vienna. The meeting is co-sponsored by the IAU Working Group on Abundances in Red Giants.

webpage: http://www.astro.univie.ac.at/ galagb
contact: galagb@astro.univie.ac.at
submitted by: Dr.Thomas Lebzelter

Abstract Guidelines

Abstracts for *COOLNEWS* are solicited for papers that have been recently accepted by or submitted to refereed journals, and for recent Ph.D. theses. Abstracts for conference proceedings articles are *not* posted in *COOLNEWS*. The subject matter should pertain directly to cool stars (spectral types F,G,K,M or L), substellar objects, or the sun. Both theoretical and observational abstracts are appropriate.

Abstracts dealing with cool pre-main-sequence (PMS) stars will generally not be included in *COOLNEWS*, since they are already covered by the *Star Formation Newsletter*. Exceptions to this rule will be considered if the subject matter is truly cross-disciplinary. If you wish to submit a cross-disciplinary abstract on PMS stars, then first submit it to the *Star Formation Newsletter*. After doing so, submit the abstract to *COOLNEWS* accompanied by a short e-mail stating that it has already been submitted to the *Star Formation Newsletter*, and summarizing why it will be of interest to the cool star/solar community at large.

A monthly call for abstracts will be issued and abstracts received by the last day of the month will usually appear in the following month's newsletter. Announcements of general interest to the cool star and solar communities may also be submitted for posting in the newsletter. These might include (but are not restricted to) the following: (i) *Job Openings* directed toward cool star or solar researchers, (ii) announcements of *Upcoming Meetings*, (iii) announcements of *Upcoming Observing Campaigns* for which participation is solicited from the community at large, (iv) reviews of *New Books*, and (v) *General Announcements* that provide or request research-related information. Please send all correspondence to the editor at coolnews@jila.colorado.edu. Abstract templates and back issues can be obtained from the COOLNEWS Web-page at

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