COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

A New VLA-*Hipparcos* Distance to Betelgeuse and its Implications[3]

Graham M. Harper[1], Alexander Brown[1] and Edward F. Guinan[2]

[1] Center for Astrophysics and Space Astronomy, University of Colorado, Boulder, CO 80309
[2] Department of Astronomy and Astrophysics, Villanova University, PA 19085
[3] The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

The distance to the M supergiant Betelgeuse is poorly known, with the *Hipparcos* parallax having a significant uncertainty. For detailed numerical studies of M supergiant atmospheres and winds, accurate distances are a prerequisite to obtaining reliable estimates for many stellar parameters. New high spatial resolution, multiwavelength, NRAO VLA radio positions of Betelgeuse have been obtained and then combined with *Hipparcos* Catalogue Intermediate Astrometric Data to derive new astrometric solutions. These new solutions indicate a smaller parallax and hence greater distance (197 ± 45 pc), than that given in the original *Hipparcos* Catalogue (131 ± 30 pc) and in the revised *Hipparcos* reduction. They also confirm smaller proper motions in both right ascension and declination, as found by previous radio observations. We examine the consequences of the revised astrometric solution on Betelgeuse's interaction with its local environment, on its stellar properties, and its kinematics. We find that the most likely star formation scenario for Betelgeuse is that it is a runaway star from the Ori OB1 association and was originally a member of a high mass multiple system within Ori OB1a.

Accepted by AJ

For preprints contact: graham.harper@Colorado.edu

From Solar and Stellar Flares to Coronal Heating: Theory and Observations of How Magnetic Reconnection Regulates Coronal Conditions

P. A. Cassak[1], D. J. Mullan[1] and M. A. Shay[1]

[1] Department of Physics and Astronomy and Bartol Research Institute, 217 Sharp Laboratory, University of Delaware, Newark, DE 19716 USA

There is currently no explanation of why the corona has the temperature and density it has. We present a model which explains how the dynamics of magnetic reconnection regulates the conditions in the corona. A bifurcation in magnetic reconnection at a critical state enforces an upper bound on the coronal temperature for a given density. We present observational evidence from 107 flares in 37 sun-like stars that stellar coronae are near this critical state. The model may be important to self-organized criticality models of the solar corona.

Accepted by ApJL

For preprints contact: pcassak@udel.edu

For preprints via ftp or WWW: http://lanl.arxiv.org/abs/ 0710.3399

Doppler Imaging of the Young Late-type Star LO Pegasi (BD+22°4409) in September 2003

N. Piluso[1,2], A. F. Lanza[2], I. Pagano[2], A. C. Lanzafame[1], J.-F. Donati[3]

[1] Sezione Astrofisica, Dipartimento di Fisica e Astronomia, Università degli Studi di Catania, Via S. Sofia, 78, 95123, Catania, Italy

[2] INAF-Osservatorio Astrofisico di Catania, Via S. Sofia, 78, 95123, Catania, Italy

[3] LATT - CNRS / Universite de Toulouse, 14 avenue E. Belin, F-31400 Toulouse, France

A Doppler image of the ZAMS late-type rapidly rotating star LO Pegasi, based on spectra acquired between 12 and 15 September 2003, is presented. The Least Square Deconvolution technique is applied to enhance the signal-to-noise ratio of the mean rotational broadened line profiles extracted from the observed spectra. In the present application, a unbroadened spectrum is used as a reference, instead of a simple line list, to improve the deconvolution technique applied to extract the mean profiles. The reconstructed image is similar to those previously obtained from observations taken in 1993 and 1998, and shows that LO Peg photospheric activity is dominated by high-latitude spots with a non-uniform polar cap. The latter seems to be a persistent feature as it has been observed since 1993 with little modifications. Small spots, observed between $\sim 10°$ and $\sim 60°$ of latitude, appears to be different with respect to those present in the 1993 and 1998 maps.

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For preprints contact: nuccio.lanza@oact.inaf.it

For preprints via ftp or WWW: http://arxiv.org/abs/0802.3957

Modelling Solar-like Variability for the Detection of Earth-like Planetary Transits. I. Performance of the Three-spot Modelling and Harmonic Function Fitting

A. S. Bonomo[1,2], A. F. Lanza[2]

[1] Dipartimento di Fisica e Astronomia, Sezione Astrofisica, Università degli Studi di Catania

[2] INAF-Osservatorio Astrofisico di Catania, Via S. Sofia, 78 – 95123 Catania, Italy

We present a comparison of two methods of fitting solar-like variability to increase the efficiency of the detection of Earth-like planetary transits across the disc of a Sun-like star. One of them is the harmonic fitting method that coupled with the Box fitting Least-Square (BLS) detection algorithm demonstrated the best performance during the first CoRoT blind test. We apply a Monte Carlo approach by simulating a large number of light curves of duration 150 days for different values of planetary radius, orbital period, epoch of the first transit, and standard deviation of the photon shot noise. Stellar variability is assumed in all the cases to be given by the Total Solar Irradiance variations as observed close to the maximum of solar cycle 23. After fitting solar variability, transits are searched for by means of the BLS algorithm. We find that a model based on three point-like active regions reduces the impact of stellar microvariability more effectively than a best fit with a linear combination of 200 harmonic functions provided that the

standard deviation of the noise is $2-4$ times larger than the central depth of the transits. On the other hand, the 200-harmonic fit is better when the standard deviation of the noise is comparable to the transit depth. Our results show the advantage of a model that includes a simple but physically motivated treatment of stellar microvariability for the detection of planetary transits, when the standard deviation of the photon shot noise is greater than the transit depth and stellar variability is analogous to solar irradiance variations.

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For preprints contact: aldo.bonomo@oact.inaf.it

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Geometry Diagnostics of a Stellar Flare from Fluorescent X-Rays

Paola Testa[1], Jeremy J. Drake[2], Barbara Ercolano[2], Fabio Reale[3,4], David P. Huenemoerder[1], Laura Affer[3,4], Giusi Micela[4] and David Garcia-Alvarez[2,5]

[1] Massachusetts Institute of Technology, Kavli Institute for Astrophysics and Space Research, 70 Vassar Street, Cambridge, MA 02139; testa@space.mit.edu

[2] Smithsonian Astrophysical Observatory, MS 3, 60 Garden Street, Cambridge, MA 02138 [3] Dipartimento di Scienze Fisiche e Astronomiche, Universit di Palermo Piazza del Parlamento 1, 90134 Palermo, Italy

[4] INAF-Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo, Italy

[5] Imperial College London, Blackett Laboratory, Prince Consort Road, London SW7 2AZ, UK

We present evidence of Fe fluorescent emission in the Chandra HETGS spectrum of the single G-type giant HR 9024 during a large flare. In analogy to solar X-ray observations, we interpret the observed Fe Kα line as being produced by illumination of the photosphere by ionizing coronal X-rays, in which case, for a given Fe photospheric abundance, its intensity depends on the height of the X-ray source. The HETGS observations, together with three-dimensional Monte Carlo calculations to model the fluorescence emission, are used to obtain a direct geometric constraint on the scale height of the flaring coronal plasma. We compute the Fe fluorescent emission induced by the emission of a single flaring coronal loop that well reproduces the observed X-ray temporal and spectral properties according to a detailed hydrodynamic modeling. The predicted Fe fluorescent emission is in good agreement with the observed value within observational uncertainties, pointing to a scale height $<0.3R_\star$. Comparison of the HR 9024 flare with that recently observed on II Peg by Swift indicates the latter is consistent with excitation by X-ray photoionization.

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For preprints contact: ptesta@cfa.harvard.edu

Solar Abstracts

Improved Constraints on the Preferential Heating and Acceleration of Oxygen Ions in the Extended Solar Corona

Steven R. Cranmer[1], Alexander V. Panasyuk[1], and John L. Kohl[1]

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

We present a detailed analysis of oxygen ion velocity distributions in the extended solar corona, based on observations made with the Ultraviolet Coronagraph Spectrometer (UVCS) on the *SOHO* spacecraft. Polar coronal holes at solar minimum are known to exhibit broad line widths and unusual intensity ratios of the O VI $\lambda\lambda$1032, 1037 emission line doublet. The traditional interpretation of these features has been that oxygen ions have a strong temperature anisotropy, with the temperature perpendicular to the magnetic field being much larger than the temperature parallel to the field. However, recent work by Raouafi and Solanki suggested that it may be possible to model the observations using an isotropic velocity distribution. In this paper we analyze an expanded data set to show that the original interpretation of an anisotropic distribution is the only one that is fully consistent with the observations. It is necessary to search the full range of ion plasma parameters to determine the values with the highest probability of agreement with the UVCS data. The derived ion outflow speeds and perpendicular kinetic temperatures are consistent with earlier results, and there continues to be strong evidence for preferential ion heating and acceleration with respect to hydrogen. At heliocentric heights above 2.1 solar radii, every UVCS data point is more consistent with an anisotropic distribution than with an isotropic distribution. At heights above 3 solar radii, the exact probability of isotropy depends on the electron density chosen to simulate the line-of-sight distribution of O VI emissivity. The most realistic electron densities (which decrease steeply from 3 to 6 solar radii) produce the lowest probabilities of isotropy and most-probable temperature anisotropy ratios that exceed 10. We also use UVCS O VI absolute intensities to compute the frozen-in O^{5+} ion concentration in the extended corona; the resulting range of values is roughly consistent with recent downward revisions in the oxygen abundance.

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For preprints contact: scranmer@cfa.harvard.edu

For preprints via ftp or WWW: http://arXiv.org/abs/0802.0144

Hyperdiffusion as a Mechanism for Solar Coronal Heating

A. A. van Ballegooijen[1] and S. R. Cranmer[1]

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

A theory for the heating of coronal magnetic flux ropes is developed. The dissipated magnetic energy has two distinct contributions: (1) energy injected into the corona as a result of granule-scale, random footpoint motions, and (2) energy from the large-scale, nonpotential magnetic field of the flux rope. The second type of dissipation can be described in term of hyperdiffusion, a type of magnetic diffusion in which the helicity of the mean magnetic field is conserved. The associated heating rate depends on the gradient of the torsion parameter of the mean magnetic field. A simple model of an active region containing a coronal flux rope is constructed. We find that the temperature and density on the axis of the flux rope are lower than in the local surroundings, consistent with observations of coronal cavities. The model requires that the magnetic field in the flux rope is stochastic in nature, with a perpendicular length scale of the magnetic fluctuations of order 1000 km.

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For preprints contact: avanballegooijen@cfa.harvard.edu

For preprints via ftp or WWW: http://arXiv.org/abs/0802.1751

Discovery of Spatial Periodicities in a Coronal Loop Using Automated Edge-tracking Algorithms

D.B. Jess[1], M. Mathioudakis[1], R. Erdelyi[2], G. Verth[2], R.T.J. McAteer[3] and F.P. Keenan[1]

[1] Astrophysics Research Center, School of Mathematics and Physics, Queens University Belfast, Belfast BT7 1NN, Northern Ireland
[2] SP^{2}RC, Department of Applied Mathematics, The Universty of Sheffield, Sheffield, S3 7RH, England, UK
[3] NASA GSFC, Solar Physics Laboratory, Code 671, Greenbelt, MD 20771, USA

A new method for automated coronal loop tracking, in both spatial and temporal domains, is presented. Applying this technique to TRACE data, obtained using the 171Å filter on 1998 July 14, we detect a coronal loop undergoing a 270 s kink-mode oscillation as previously found by Aschwanden et al (1999). However, we also detect flare-induced, and previously unnoticed, *spatial periodicities* on a scale of 3500 km, which occur along the coronal-loop edge. Furthermore, we establish a reduction in oscillatory power, for these spatial periodicities, of 45% over a 222 s interval. We relate the reduction in detected oscillatory power to the physical damping of these loop-top oscillations.

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For preprints contact: djess01@qub.ac.uk

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Small-scale Flows in SUMER and TRACE High-cadence Co-Observations

M.S. Madjarska[1], J.G. Doyle[2]

[1] Max-Planck-Institut für Sonnensystemforschung, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany
[2] Armagh Observatory, College Hill, Armagh BT61 9DG, N. Ireland

We report on the physical properties of small-scale transient flows observed simultaneously at high cadence with the SUMER spectrometer and the TRACE imager in the plage area of an active region. Our major objective is to provide a better understanding of the nature of transient phenomena in the solar atmosphere by using high-cadence imager and spectrometer co-observations at similar spatial and temporal resolution. A sequence of TRACE Fe IX/X λ171 Å and high-resolution MDI images were analysed together with simultaneously obtained SUMER observations in spectral lines covering a temperature range from 10 000 K to 1 MK. We reveal the existence of numerous transient flows in small-scale loops (up to 30 Mm) observed in the plage area of an active region. These flows have temperatures from 10 000 K (the low temperature limit of our observations) to 250 000 K. The coronal response of these features is uncertain due to a blending of the observed coronal line Mg X λ624.85 Å. The duration of the events ranges from 60 s to 19 min depending on the loop size. Some of the flows reach supersonic velocities. The Doppler shifts often associated with explosive events or bi-directional jets can actually be identified with flows (some of them reaching supersonic velocities) in small-scale loops. Additionally, we demonstrate how a line-of-sight effect can give misleading information on the nature of the observed phenomena if only either an imager or a spectrometer is used.

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For preprints contact: jgd@arm.ac.uk

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Low-Mass and Substellar Abstracts

New Brown Dwarf Disks in the TW Hydrae Association

Basmah Riaz[1] and John E. Gizis[1]

[1] Department of Physics and Astronomy, University of Delaware, Newark, DE 19716

In our analysis of *Spitzer*/IRS archival data on the stellar and sub-stellar members of the TW Hydrae Association (TWA), we have discovered two new brown dwarf disks: a flat optically thick disk around SSSPM J1102-3431 (SSSPM 1102), and a transition disk around 2MASS J1139511-315921 (2M1139). The disk structure for SSSPM 1102 is found to be very similar to the known brown dwarf disk 2MASSW J1207334-393254 (2M1207), with excess emission observed at wavelengths as short as 5 μm. 2M1139 shows no excess emission shortward of $\sim$20 μm, but flares up at longer wavelengths, and is the first transition disk detected among the sub-stellar members of TWA. We also report on the *Spitzer*/70 μm observations, and the presence of an *absorption* 10 μm silicate feature for 2M1207. The absorption can be attributed to a close to edge-on disk at a 75deg inclination. The 10 μm spectrum for 2M1207 shows crystalline forsterite features, with a peak in absorption near 11.3 μm. No silicate absorption/emission is observed towards SSSPM 1102. While only 6 out of 25 stellar members show excess emission at these mid-infrared wavelengths, *all* of the TWA brown dwarfs that have been observed so far with *Spitzer* show signs of disks around them, resulting in a disk fraction of at least 60%. This is a considerable fraction at a relatively older age of $\sim$10 Myr. A comparison with younger clusters indicates that by the age of the TWA ($\sim$10 Myr), the disk fraction for brown dwarfs has not decreased, whereas it drops by a factor of $\sim$2 for the higher mass stars. This suggests longer disk decay time scales for brown dwarfs compared to higher mass stars.

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For preprints contact: basmah@udel.edu

Structure and Evolution of Super-Earth to Super-Jupiter Exoplanets: I. Heavy Element Enrichment in the Interior

Isabelle Baraffe[1], **Gilles Chabrier**[1] **and Travis Barman**[2]

[1] École normale supérieure de Lyon, CRAL (CNRS), 46 allée d'Italie, 69007 Lyon, Université de Lyon, France
[2] Lowell observatory, 1400 West Mars Hill Road, Flagstaff, AZ 86001, USA

We examine the uncertainties in current planetary models and quantify their impact on the planet cooling histories and mass-radius relationships. These uncertainties include (i) the differences between the various equations of state used to characterize the heavy material thermodynamical properties, (ii) the distribution of heavy elements within planetary interiors, (iii) their chemical composition, and (iv) their thermal contribution to the planet evolution. Our models, which include a gaseous H/He envelope, are compared with models of solid, gasless Earth-like planets in order to examine the impact of a gaseous envelope on the cooling and the resulting radius. We find that, for a fraction of heavy material larger than 20% of the planet mass, the distribution of the heavy elements in the planet's interior substantially affects the evolution and thus the radius at a given age. For planets with large core mass fractions ($\gtrsim$ 50%), such as the Neptune-mass transiting planet GJ436b, the contribution of the gravitational and thermal energy from the core to the planet cooling history is not negligible, yielding a $\sim$ 10% effect on the radius after 1 Gyr. We show that the present mass and radius determinations of the massive planet Hat-P-2b require at least 200 $M_\oplus$ of heavy material in the interior, at the edge of what is currently predicted by the core-accretion model for planet formation. As an alternative avenue for massive planet formation, we suggest that this planet, and similarly HD 17156b, may have formed from collisions between one or several other massive planets. This would explain these planets unusually high density and high eccentricity. We show that if planets as massive as $\sim 25\ M_\mathrm{J}$ can form, as predicted by improved core-accretion models, deuterium is able to burn in the H/He layers above the core, even for core masses as high as $\sim$ 100 $M_\oplus$. Such a result highlights the confusion provided by a definition of a planet based on the deuterium-burning limit. We provide extensive grids of planetary evolution models from 10 $M_\oplus$ to 10 M_Jup, with various fractions of heavy elements. These models provide a reference for analyzing the transit discoveries expected from the CoRoT and Kepler missions and for inferring the internal composition of these objects

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*For preprints contact:*ibaraffe@ens-lyon.fr

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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