COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

No. 198 — July - Aug. 2015 Editor: Steve Skinner (coolnews@jila.colorado.edu)

TABLE OF CONTENTS

Stellar Abstracts 1
Solar Abstracts 3
Abstract Guidelines 6

Coolnews on the Web

The current and previous issues of *Coolnews* are available on the following web page in pdf, postscript, and Latex format: **http://casa.colorado.edu/~skinners/coolnews.html**

Stellar Abstracts

The GAPS Programme with HARPS-N at TNG. X. Differential Abundances in the XO-2 Planet Hosting Binary

K. Biazzo[1], R. Gratton[2], S. Desidera[2], S. Lucatello[2], A. Sozzetti[3], A. S. Bonomo[3], M. Damasso[3], D. Gandolfi[4,5], L. Affer[6], C. Boccato[2], F. Borsa[7], R. Claudi[2], R. Cosentino[1,8], E. Covino[9], C. Knapic[10], A. F. Lanza[1], J. Maldonado[6], F. Marzari[11], G. Micela[6], P. Molaro[10], I. Pagano[1], M. Pedani[8], I. Pillitteri[6], G. Piotto[2,11], E. Poretti[7], M. Rainer[7], N. C. Santos[12,13,14], G. Scandariato[1] and R. Zanmar Sanchez[1]

[1] INAF - Osservatorio Astrofisico di Catania, Via S. Sofia 78, I-95123 Catania, Italy
[2] INAF - Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, I-35122 Padova, Italy
[3] INAF - Osservatorio Astrofisico di Torino, Via Osservatorio 20, I-10025 Pino Torinese, Italy
[4] Dipartimento di Fisica, Università di Torino, Via P. Giuria 1, I-10125 Torino, Italy
[5] Landessternwarte Königstuhl, Zentrum für Astronomie der Universitat Heidelberg, Königstuhl 12, D-69117 Heidelberg, Germany
[6] INAF - Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, I-90134 Palermo, Italy
[7] INAF - Osservatorio Astronomico di Brera, Via E. Bianchi 46, I-23807 Merate (LC), Italy
[8] Fundación Galileo Galilei - INAF, Rambla José Ana Fernandez Pérez 7, E-38712 Breña Baja, TF - Spain
[9] INAF - Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, I-80131 Napoli, Italy
[10] INAF - Osservatorio Astronomico di Trieste, Via Tiepolo 11, I-34143 Trieste, Italy
[11] Dipartimento di Fisica e Astronomia Galileo Galilei - Università di Padova, Vicolo dell'Osservatorio 2, I-35122, Padova, Italy
[12] Instituto de Astrofísica e Ciências do Espaço, Universitade do Porto, CAUP, Rua das Estrelas, 4150-762 Porto, Portugal
[13] Centro de Astrofísica, Universitade do Porto, Rua das Estrelas, 4150-762 Porto, Portugal
[14] Departamento de Física e Astronomia, Facultade de Ciências, Univ. do Porto, Rua do Campo Alegre, s/n, 4169-007 Porto, Portugal

Binary stars hosting exoplanets are a unique laboratory where chemical tagging can be performed to measure with high accuracy the elemental abundances of both stellar components, with the aim to investigate the formation of planets and their subsequent evolution. Here, we present a high-precision differential abundance analysis of the XO-2 wide stellar binary based on high resolution HARPS-N@TNG spectra. Both components are very similar K-dwarfs and host planets. Since they formed presumably within the same molecular cloud, we expect they should possess the same initial elemental abundances. We investigate if the presence of planets can cause some chemical imprints in the stellar atmospheric abundances. We measure abundances of 25 elements for both stars with a range of condensation temperature $T_{\rm C} = 40 - 1741$ K, achieving typical precisions of ~ 0.07 dex. The North component shows abundances in all elements higher by $+0.067 \pm 0.032$ dex on average, with a mean difference of $+0.078$ dex for elements with $T_{\rm C} > 800$ K. The significance of the XO-2N abundance difference relative to XO-2S is at the 2σ level for almost all elements. We discuss the possibility that this result could be interpreted as the signature of the ingestion of material by XO-2N or depletion in XO-2S due to locking of heavy elements by the planetary companions. We estimate a mass of several tens of $M_\oplus$ in heavy elements. The difference in abundances between XO-2N and XO-2S shows a positive correlation with the condensation temperatures of the elements, with a slope of $(4.7 \pm 0.9) \times 10^{-5}$ dex K^{-1}, which could mean that both components have not formed terrestrial planets, but that first experienced the accretion of rocky core interior to the subsequent giant planets.

Accepted by A&A

For preprints contact: katia.biazzo@oact.inaf.it

Coordinated X-ray and Optical Observations of Star-Planet Interaction in HD 17156

A. Maggio[1], I. Pillitteri[1,2], G. Scandariato[3], A.F. Lanza[3], S. Sciortino[1], F. Borsa[4], A.S. Bonomo[5], R. Claudi[6], E. Covino[7], S. Desidera[6], R. Gratton[6], G. Micela[1], I. Pagano[3], G. Piotto[6,8], A. Sozzetti[5], R. Cosentino[9] and J. Maldonado[1]

[1] INAF – Osservatorio Astronomico di Palermo, piazza del Parlamento 1, I–90134 Palermo, Italy
[2] SAO–Harvard Center for Astrophysics, Cambridge, MA 02138, USA
[3] INAF – Osservatorio Astrofisico di Catania, Italy
[4] INAF – Osservatorio Astronomico di Brera, Milano, Italy
[5] INAF - Osservatorio Astrofisico di Torino, Pino Torinese, Italy
[6] INAF – Osservatorio Astronomico di Padova, Italy
[7] INAF – Osservatorio Astronomico di Capodimonte, Italy
[8] Dip. di Fisica e Astronomia G. Galilei – Università di Padova, Italy
[9] Fundación Galileo Galilei – INAF, Breña Baja, TF–Spain

The large number of close-in Jupiter-size exoplanets prompts the question whether star–planet interaction (SPI) effects can be detected. We focused our attention on the system HD 17156, having a Jupiter-mass planet in a very eccentric orbit. Here we present results of the *XMM-Newton* observations and of a five months coordinated optical campaign with the HARPS-N spectrograph, based on observations collected at the Italian Telescopio Nazionale Galileo (TNG), operated on the island of La Palma by the Fundanción Galileo Galilei of the INAF (Istituto Nazionale di Astrofisica), in the frame of the programme *Global Architecture of Planetary Systems* (GAPS). We observed HD 17156 with *XMM-Newton* when the planet was approaching the apoastron and then at the following periastron passage, quasi simultaneously with HARPS-N. We obtained a clear ($\approx 5.5\sigma$) X-ray detection only at the periastron visit, accompanied by a significant increase of the $R'_{\rm HK}$ chromospheric index. We discuss two possible scenarios for the activity enhancement: magnetic reconnection and flaring or accretion onto the star of material tidally stripped from the planet. In any case, this is possibly the first evidence of a magnetic SPI effect caught in action.

Accepted by ApJ (2015 ApJ, 811, L2)

For preprints contact: maggio@astropa.inaf.it

Solar Radius Variations: an Inquisitive Wavelength Dependence

Jean-Pierre Rozelot[1], Alexander Kosovichev[2] and Ali Kilcik[3]

[1] Nice University, 77 Ch. des Basses Moulières, 06130 Grasse, France
[2] New Jersey Institute of Technology, Newark, NJ 07103 USA
[3] Department of Space Science and Technologies, Akdeniz University, 07058 Antalya, Turkey,

Recent solar radius determinations from space observation of Mercury and Venus transits have been made by different teams, in 2003, 2006, 2012 and 2014. Seemingly the results are not consistent: the authors interpreted the discrepancies as caused by the different methods of analysis. However, looking at the wavelength dependence and adding other available observations, from X-EUV up to radio, a typical wavelength dependence can be found, reflecting the different heights at which the lines are formed. Measurements obtained during different periods of time would, in principle, allow us to detect a signature of a radius temporal dependence. However, the available data are not sufficiently numerous to detect a significant dependence, at least at the level of the uncertainty at which the observations were made. Lastly, no unique theoretical model is available today to reproduce the strong wavelength dependence of the solar radius, which shows an unexpected minimum at around (6.6 1.9) μm, after a parabolic fit.

Accepted by ApJ

For preprints contact: jp.rozelot@orange.f

Numerical MHD Simulation of the Coupled Evolution of Collisional Plasma and Magnetic Field in the Solar Chromosphere. I. Gradual and Impulsive Energisation

L.M. Alekseeva[1] and S.P. Kshevetskii[2]

[1] Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, Moscow, 119991 Russia
[2] Immanuel Kant Baltic Federal University, Kaliningrad, 236041 Russia

The dynamical coupling between the solar chromospheric plasma and magnetic field is investigated by numerically solving a fully self-consistent, two-dimensional initial-value problem for the nonlinear collisional MHD equations including electric resistivity, thermal conduction, and, in some cases, gas-dynamic viscosity. The processes in the contact zone between two horizontal magnetic fields of opposite polarities are considered. The plasma is assumed to be initially motionless and having a temperature of 50,000 K uniform throughout the plasma volume; the characteristic magnetic field corresponds to a plasma $\beta \geq 1$. In a physical-time interval of 17 seconds typically covered by a computational run, the plasma temperature gradually increases by a factor of two to three. Against this background, an impulsive (in 0.1 seconds or less) increase in the current-aligned plasma velocity occurs at the site of the current-layer thinning (sausage-type deformation, or $m = 0$ pinch instability). Such a "velocity burst" can be interpreted physically as an event of suprathemal-proton generation. Further development of the sausage instability results in an increase in the kinetic temperature of the protons to high values, even to those observed in flares. The form of our system of MHD equations indicates that such increases are a property of the exact solution of the system at an appropriate choice of the parameters. Magnetic reconnection does not manifest itself in this solution: it would generate flows forbidden by the chosen geometry. Therefore, the pinch-sausage effect can act as an energiser of the upper chromosphere and be an alternative to the magnetic-reconnection process as the producer of flares.

Accepted by Solar Physics

For preprints via WWW: http://arxiv.org/abs/1508.03626

Driving Solar Spicules and Jets with Magnetohydrodynamic Turbulence: Testing a Persistent Idea

Steven R. Cranmer[1] and Lauren N. Woolsey[2]

[1] Department of Astrophysical and Planetary Sciences, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80309, USA

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

The solar chromosphere contains thin, highly dynamic strands of plasma known as spicules. Recently, it has been suggested that the smallest and fastest (Type II) spicules are identical to intermittent jets observed by the *Interface Region Imaging Spectrograph.* These jets appear to expand out along open magnetic field lines rooted in unipolar network regions of coronal holes. In this paper we revisit a thirty-year-old idea that spicules may be caused by upward forces associated with Alfvén waves. These forces involve the conversion of transverse Alfvén waves into compressive acoustic-like waves that steepen into shocks. The repeated buffeting due to upward shock propagation causes nonthermal expansion of the chromosphere and a transient levitation of the transition region. Some older models of wave-driven spicules assumed sinusoidal wave inputs, but the solar atmosphere is highly turbulent and stochastic. Thus, we model this process using the output of a time-dependent simulation of reduced magnetohydrodynamic turbulence. The resulting mode-converted compressive waves are strongly variable in time, with a higher transition region occurring when the amplitudes are large and a lower transition region when the amplitudes are small. In this picture, the transition region bobs up and down by several Mm on timescales less than a minute. These motions produce narrow, intermittent extensions of the chromosphere that have similar properties as the observed jets and Type II spicules.

Accepted by ApJ

For preprints contact: steven.cranmer@colorado.edu

For preprints via WWW: http://arXiv.org/abs/1509.03263

The Photospheric Solar Oxygen Project: IV. 3D-NLTE Investigation of the 777 nm Triplet Lines

M. Steffen[1,3], D. Prakapavičius[2], E. Caffau[3], H.-G. Ludwig[4,3], P. Bonifacio[3], R. Cayrel[3], A. Kučinskas[2,5], W.C. Livingston[6]

[1] Leibniz-Institut für Astrophysik Potsdam, An der Sternwarte 16, D-14482 Potsdam, Germany

[2] Institute of Theoretical Physics and Astronomy, Vilnius University, A. Goštauto 12, Vilnius LT-01108, Lithuania

[3] GEPI, Observatoire de Paris, CNRS, Université Paris Diderot, Place Jules Janssen, 92190 Meudon, France

[4] ZAH Landessternwarte Königstuhl, D-69117 Heidelberg, Germany

[5] Astronomical Observatory, Vilnius University, M. K. Čiurlionio 29, Vilnius LT-03100, Lithuania

[6] National Solar Observatory, 950 North Cherry Avenue, Tucson, AZ 85719, USA

The solar photospheric oxygen abundance is still widely debated. Adopting the solar chemical composition based on the "low" oxygen abundance, as determined with the use of three-dimensional (3D) hydrodynamical model atmospheres, results in a well-known mismatch between theoretical solar models and helioseismic measurements that is so far unresolved.

We carry out an independent redetermination of the solar oxygen abundance by investigating the center-to-limb variation of the OI IR triplet lines at 777 nm in different sets of spectra with the help of detailed synthetic line profiles based on 3D hydrodynamical CO5BOLD model atmospheres and 3D non-LTE line formation calculations with NLTETD. The idea is to simultaneously derive the oxygen abundance,A(O), and the scaling factor SH that describes the cross-sections for inelastic collisions with neutral hydrogen relative the classical Drawin formula.

The best fit of the center-to-limb variation of the triplet lines achieved with the CO5BOLD 3D solar model is clearly of superior quality compared to the line profile fits obtained with standard 1D model atmospheres.

Our best estimate of the 3D non-LTE solar oxygen abundance is A(O) = 8.76 +/- 0.02, with the scaling factor SH in the range between 1.2 and 1.8. All 1D non-LTE models give much lower oxygen abundances, by up to -0.15 dex. This is mainly a consequence of the assumption of a μ-independent microturbulence.

An independent determination of the relevant collisional cross-sections is essential to further improve the accuracy of the oxygen abundance derived from the OI IR triplet.

Accepted by A&A

For preprints contact: msteffen@aip.de

For preprints via WWW: http://arxiv.org/abs/1508.03487

The Maunder Minimum (1645–1715) Was Indeed a Grand Minimum: A Reassessment of Multiple Datasets

Ilya G. Usoskin[1,2], Rainer Arlt[3], Eleanna Asvestari[1], Ed Hawkins[6], Maarit Käpylä[7], Gennady A. Kovaltsov[4], Natalie Krivova[5], Michael Lockwood[6], Kalevi Mursula[1], Jezebel O'Reilly[6], Matthew Owens[6], Chris J. Scott[6], Dmitry D. Sokoloff[8,9], Sami K. Solanki[5,10], Willie Soon[11] and José M. Vaquero[12]

[1] ReSoLVE Centre of Excellence, University of Oulu, Finland

[2] Sodankylä Geophysical Observatory, University of Oulu, Finland

[3] Leibniz Institute for Astrophysics Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany

[4] Ioffe Physical-Technical Instituture, St. Petersburg, Russia

[5] Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany

[6] Department of Meteorology, University of Reading, U.K.

[7] ReSoLVE Centre of Excellence, Department of Computer Science, PO BOX 15400, Aalto University FI-00076 Aalto, Finland

[8] Moscow State University, Moscow, Russia

[9] IZMIRAN, Moscow, Russia

[10] School of Space Research, Kyung Hee University, Yongin, Gyeonggi 446-701, Republic of Korea

[11] Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA

[12] Departamento de Física, Universidad de Extremadura, Mérida (Badajoz), Spain

Although the time of the Maunder minimum (1645–1715) is widely known as a period of extremely low solar activity, claims are still debated that solar activity during that period might still have been moderate, even higher than the current solar cycle # 24. We have revisited all the existing pieces of evidence and datasets, both direct and indirect, to assess the level of solar activity during the Maunder minimum.

We discuss the East Asian naked-eye sunspot observations, the telescopic solar observations, the fraction of sunspot active days, the latitudinal extent of sunspot positions, auroral sightings at high latitudes, cosmogenic radionuclide data as well as solar eclipse observations for that period. We also consider peculiar features of the Sun (very strong hemispheric asymmetry of sunspot location, unusual differential rotation and the lack of the K-corona) that imply a special mode of solar activity during the Maunder minimum. The level of solar activity during the Maunder minimum is reassessed on the basis of all available data sets.

We conclude that solar activity was indeed at an exceptionally low level during the Maunder minimum. Although the exact level is still unclear, it was definitely below that during the Dalton minimum around 1800 and significantly below that of the current solar cycle # 24. Claims of a moderate-to-high level of solar activity during the Maunder minimum are rejected at a high confidence level.

Accepted by A&A (2015, 581, A95); doi: 10.1051/0004-6361/201526652

For preprints contact: ilya.usoskin@oulu.fi

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

`http://casa.colorado.edu/~skinners/coolnews.html` .

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