COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

The Gaia-ESO Survey: Chromospheric Emission, Accretion Properties, and Rotation in γ Velorum and Chamaeleon I

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One of the scopes of the Gaia-ESO Survey (GES), which is conducted with FLAMES at the VLT, is the census and the characterization of the low-mass members of very young clusters and associations. We conduct a comparative study of the main properties of the sources belonging to γ Velorum (γ Vel) and Chamaeleon I (Cha I) young associations, focusing on their rotation, chromospheric radiative losses, and accretion. We use the fundamental parameters (effective temperature, surface gravity, lithium abundance, and radial velocity) delivered by the GES consortium in the first internal data release to select the members of γ Vel and Cha I among the UVES and GIRAFFE spectroscopic observations. A total of 140 γ Vel members and 74 Cha I members were studied. The procedure adopted by the GES to derive stellar fundamental parameters provided also measures of the projected rotational velocity ($v\sin i$). We calculated stellar luminosities through spectral energy distributions, while stellar masses were derived by comparison with evolutionary tracks. The spectral subtraction of low-activity and slowly rotating templates, which are rotationally broadened to match the $v\sin i$ of the targets, enabled us to measure the equivalent widths (EWs) and the fluxes in the Hα and Hβ lines. The Hα line was also used for identifying accreting objects, on the basis of its equivalent width and the width at the 10% of the line peak (10%W), and for evaluating the mass accretion rate ($\dot{M}_{\rm acc}$). The distribution of $v\sin i$ for the members of γ Vel displays a peak at about 10 $\rm km\,s^{-1}$ with a tail toward faster rotators. There is also some indication of a different $v\sin i$ distribution for the members of its two kinematical populations. Most of these stars have Hα fluxes corresponding to a saturated activity regime. We find a similar distribution, but with a narrower peak, for Cha I. Only a handful of stars in γ Vel display signatures of accretion, while many more accretors were detected in the younger Cha I, where the highest Hα fluxes are mostly due to accretion, rather than to chromospheric activity. Accreting and active stars occupy two different regions in a $T_{\rm eff}$–flux diagram and we propose a criterion for distinguishing them. We derive $\dot{M}_{\rm acc}$ in the ranges 10^{-11}–$10^{-9}M_\odot\,{\rm yr}^{-1}$ and 10^{-10}–$10^{-7}M_\odot\,{\rm yr}^{-1}$ for γ Vel and Cha I accretors, respectively. We find less scatter in the $\dot{M}_{\rm acc} - M_\star$ relation derived through the Hα EWs, when compared to the Hα 10%W diagnostics, in agreement with other authors.

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For preprints via WWW: http://arxiv.org/abs/1412.4153

Near Infrared Spectroscopy of M Dwarfs. II. H_2O Molecule as an Abundance Indicator of Oxygen

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Based on the near infrared spectra ($R \approx 20000$) of M dwarfs, oxygen abundances are determined from the ro-vibrational lines of H_2O. Although H_2O lines in M dwarfs are badly blended each other and the continuum levels are depressed appreciably by the collective effect of numerous H_2O lines themselves, quantitative analysis of H_2O lines has been carried out by referring to the pseudo-continua consistently defined by the same way on the observed and theoretical spectra. For this purpose, the pseudo-continuum on the theoretical spectrum has been evaluated accurately by the use of the recent high-precision H_2O line-list. Then, we propose a simple and flexible method of analyzing equivalent widths (EWs) of blended features (i.e., not necessarily limited to single lines) by the use of a mini curve-of-growth (CG), which is a small portion of the usual CG around the observed EW. The mini CG is generated by using the

theoretical EWs evaluated from the synthetic spectra by exactly the same way as the EWs are measured from the observed spectrum. The observed EW is converted to the abundance by the use of the mini CG, and the process is repeated for all the observed EWs line-by-line or blend-by-blend.

In cool M dwarfs, almost all the oxygen atoms left after CO formation are in stable H_2O molecules, which suffer little change for the uncertainties due to imperfect modelling of the photospheres. Moreover, the thermal velocity of H_2O is most probably larger than the micro-turbulent velocity because of its lower molecular weight, and the uncertainty of the micro-turbulent velocity will have relatively minor effect on the abundance determination. Then the numerous H_2O lines are excellent abundance indicators of oxygen, and the oxygen abundances are determined to be $\log A_{\rm O}$ ($A_{\rm O} = N_{\rm O}/N_{\rm H}$) between -3.5 and -3.0 in 38 M dwarfs. The resulting $\log A_{\rm O}/A_{\rm C}$ plotted against $\log A_{\rm C}$ appears to be systematically smaller in the carbon-rich M dwarfs, showing the different formation histories of oxygen and carbon in the chemical evolution of the Galactic disk. Also, $A_{\rm O}/A_{\rm Fe}$ratios in most M dwarfs are closer to the solar $A_{\rm O}/A_{\rm Fe}$ ratio based on the classical high oxygen abundance rather than on the recently downward revised low value. Now, carbon and oxygen abundances can best be determined in M dwarfs from the LTE analysis of CO and H_2O spectra, and M dwarfs will provide unique contribution to the cosmic abundance determination. This is in marked contrast to the caseof cool luminous stars with rarefied and extended atmospheres for whichLTE modelings are more difficult.

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S-Type and P-Type Habitability in Stellar Binary Systems: A Comprehensive Approach II. Elliptical Orbits

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In the first paper of this series, a comprehensive approach has been provided for the study of *S*-type and *P*-type habitable regions in stellar binary systems, which was, however, restricted to circular orbits of the stellar components. Fortunately, a modest modification of the method also allows for the consideration of elliptical orbits, which of course entails a much broader range of applicability. This augmented method is presented here, and numerous applications are conveyed. In alignment with Paper I, the selected approach considers a variety of aspects, which comprise the consideration of a joint constraint including orbital stability and a habitable region for a possible system planet through the stellar radiative energy fluxes ("radiative habitable zone"; RHZ). The devised method is based on a combined formalism for the assessment of both *S*-type and *P*-type habitability; in particular, mathematical criteria are deduced for which kinds of systems *S*-type and *P*-type habitable zones are realized. If the RHZs are truncated by the additional constraint of orbital stability, the notation of *ST*-type and *PT*-type habitability applies. In comparison to the circular case, it is found that in systems of higher eccentricity, the range of the RHZs is significantly reduced. Moreover, for a considerable number of models, the orbital stability constraint also reduces the range of *S*-type and *P*-type habitability. Nonetheless, *S*-, *P*-, *ST*-, and *PT*-type habitability is identified for a considerable set of system parameters. The method as presented is utilized for `BinHab`, an online code available at The University of Texas at Arlington.

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Formation of Starspots in Self-consistent Global Dynamo Models: Polar Spots on Cool Stars

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Observations of cool stars reveal dark spot-like features on their surfaces. Compared to sunspots, starspots can be bigger or cover a larger fraction of the stellar surface. While sunspots appear only at low latitudes, starspots are also found in polar regions, in particular on rapidly rotating stars. Sunspots are believed to result from the eruption of magnetic flux-tubes rising from the deep interior of the Sun. The strong magnetic field locally reduces convective heat transport to the solar surface. Such flux-tube models have also been invoked to explain starspot properties. However, these models use several simplifications and so far the generation of either sunspots or starspots has not been demonstrated in a self-consistent simulation of stellar magnetic convection. Here we show that direct numerical simulations of a distributed dynamo operating in a density-stratified rotating spherical shell can spontaneously generate cool spots. Convection in the interior of the model produces a large scale magnetic field which interacts with near surface granular convection leading to strong concentrations of magnetic flux and formation of starspots. Prerequisites for the formation of sizeable high-latitude spots in the model are sufficiently strong density stratification and rapid rotation. Our model presents an alternate mechanism for starspot formation by distributed dynamo action.

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Photometric Study of HD 155555C in the β Pictoris Association

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We are carrying out a series of photometric monitoring to measure the rotation periods of members in the young β Pictoris Association, as part of the RACE-OC project (Rotation and ACtivity Evolution in Open Clusters). In this paper, we present the results for HD 155555C which is believed to be physically associated to the spectroscopic binary V824 Ara (HD155555) and thus constituting a triple system. We collected B, V, and R-band photometric data timeseries and discovered from periodogram analysis the rotation period P = 4.43 d. Combined with stellar radius and projected rotational velocity, we find this star almost equator-on with an inclination $i \simeq 90°$. The rotational properties of HD155555C fit well into the period distribution of other β Pic members, giving further support to the suggested membership to the association and to its physical association to V824 Ara. A comparison with Pre-Main-Sequence isochrones from various models allows us to estimate an age of 20±15 Myr for this triple system.

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A Multi-wavelength Study of the M Dwarf Binary YY Geminorum

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We review the results of the 1988 multi-wavelength campaign on the late-type eclipsing binary YY Geminorum. Observations include: broad-band optical and near infra-red photometry, simultaneous optical and ultraviolet (IUE) spectroscopy, X-ray (Ginga) and radio (VLA) data. From models fitted to the optical light curves, fundamental physical parameters have been determined together with evidence for transient maculations (spots) located near quadrature longitudes and intermediate latitudes.

Eclipses were observed at optical, ultraviolet and radio wavelengths. Significant drops in 6cm radio emission near the phases of both primary and secondary eclipse indicate relatively compact radio emitting volumes that may lie between the binary components. IUE observations during secondary eclipse are indicative of a uniform chromosphere saturated with MgII plage-type emission and an extended volume of Lyα emission.

Profile fitting of high-dispersion Hα spectra confirms the chromospheric saturation and indicates significant Hα opacity to heights of a few percent of the photospheric radius. There is evidence for an enhanced Hα emission region visible near phase 0.25-0.35 which may be associated with a large spot on the primary and with two small optical flares which were also observed at other wavelengths: one in microwave radiation and the other in X-rays. For both flares, L_X/L_{opt} is consistent with energy release in closed magnetic structures.

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The Temperature and Chronology of Heavy-element Synthesis in Low-mass Stars

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Roughly half of the heavy elements (atomic mass greater than that of iron) are believed to be synthesized in the late evolutionary stages of stars with masses between 0.8 and 8 solar masses. Deep inside the star, nuclei (mainly iron) capture neutrons and progressively build up (through the slow-neutron-capture process, or s-process) heavier elements that are subsequently brought to the stellar surface by convection. Two neutron sources, activated at distinct temperatures, have been proposed: ^{13}C and ^{22}Ne, each releasing one neutron per α-particle captured. To explain the measured stellar abundances, stellar evolution models invoking the ^{13}C neutron source (which operates at temperatures of about one hundred million kelvin) are favoured. Isotopic ratios in primitive meteorites, however, reflecting nucleosynthesis in the previous generations of stars that contributed material to the Solar System, point to higher temperatures (more than three hundred million kelvin), requiring at least a late activation of ^{22}Ne. Here we report a determination of the s-process temperature directly in evolved low-mass giant stars, using zirconium and niobium abundances, independently of stellar evolution models. The derived temperature supports ^{13}C as the s-process neutron source. The radioactive pair ^{93}Zr–^{93}Nb used to estimate the s-process temperature also provides, together with the pair ^{99}Tc–^{99}Ru, chronometric information on the time elapsed since the start of the s-process, which we determine to be one million to three million years.

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Serendipitous Discovery of a Dwarf Nova in the Kepler Field Near the G Dwarf KIC 5438845

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The *Kepler* satellite provides a unique window into stellar temporal variability by observing a wide variety of stars with multi-year, near-continuous, high precision, optical photometric time series. While most *Kepler* targets are faint stars with poorly known physical properties, many unexpected discoveries should result from a long photometric survey of such a large area of sky. During our *Kepler* Guest Observer programs that monitored late-type stars for starspot and flaring variability, we discovered a previously unknown dwarf nova that lies within a few arcseconds of the mid-G dwarf star KIC 5438845. This dwarf nova underwent nine outbursts over a 4-year time span. The two largest outbursts lasted ∼17-18 days and show strong modulations with a 110.8 minute period and a declining amplitude during the outburst decay phase. These properties are characteristic of an SU UMa-type cataclysmic variable. By analogy with other dwarf nova lightcurves, we associate the 110.8 minute (1.847 hour) period with the superhump period, close to but slightly longer than the orbital period of the binary. No precursor outbursts are seen before the super-outbursts and the overall super-outburst morphology corresponds to Osaki & Meyer "Case B" outbursts, which are initiated when the outer edge of the disk reaches the tidal truncation radius. "Case B" outbursts are rare within the *Kepler* lightcurves of dwarf novae. The dwarf nova is undergoing relatively slow mass transfer, as evidenced by the long intervals between outbursts, but the mass transfer rate appears to be steady, because the smaller "normal" outbursts show a strong correlation between the integrated outburst energy and the elapsed time since the previous outburst. At super-outburst maximum the system was at V∼18, but in quiescence it is fainter than V∼22, which will make any detailed quiescent follow-up of this system difficult.

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Solar Abstracts

A New Method to Estimate Annual Solar Wind Parameters and Contributions of Different Stream Structures to Geomagnetic Activity

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In the declining phase of the solar cycle, when the new-polarity fields of the solar poles are strengthened by the transport of same-signed magnetic flux, the polar coronal holes expand and form non-axisymmetric extensions toward lower latitudes. These extensions enhance the occurrence of high-speed solar wind streams (HSS) and related co-rotating interaction regions in the low-latitude heliosphere and cause moderate geomagnetic activity in the near-Earth

space. Here, using a novel definition of geomagnetic activity at polar cap latitudes and the longest record of magnetic observations at a polar cap station, we calculate the annually averaged solar wind speeds as proxies for the effective annual occurrence of HSS over the whole Grand Modern Maximum (GMM) from 1920s onwards. We find that a period of high annual speeds (frequent occurrence of HSS) occurs in the declining phase of each solar cycle 16-23. For most cycles the HSS activity clearly maximizes during one year, suggesting that typically only one strong activation leading to a coronal hole extension is responsible for the HSS maximum. We find that the most persistent HSS activity occurred in the declining phase of solar cycle 18. This suggests that cycle 19, which marks the sunspot maximum period of the GMM, was preceded by exceptionally strong polar fields during the previous sunspot minimum. This gives interesting support for the validity of solar dynamo theory during this dramatic period of solar magnetism.

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A New Method to Estimate Annual Solar Wind Parameters and Contributions of Different Stream Structures to Geomagnetic Activity

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In this paper, we study two sets of local geomagnetic indices from 26 stations using the principal component (PC) and the independent component (IC) analysis methods. We demonstrate that the annually averaged indices can be accurately represented as linear combinations of two first components with weights systematically depending on latitude. We show that the annual contributions of coronal mass ejections (CMEs) and high speed streams (HSSs) to geomagnetic activity are highly correlated with the first and second IC. The first and second ICs are also found to be very highly correlated with the strength of the interplanetary magnetic field (IMF) and the solar wind speed, respectively, because solar wind speed is the most important parameter driving geomagnetic activity during HSSs while IMF strength dominates during CMEs. These results help in better understanding the long-term driving of geomagnetic activity and in gaining information about the long-term evolution of solar wind parameters and the different solar wind structures.

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Solar Surface Rotation: N-S Asymmetry and Recent Speed-up

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Context. The relation between solar surface rotation and sunspot activity still remains open. Sunspot activity has dramatically reduced in solar cycle 24 and several solar activity indices and flux measurements experienced unprecedentedly low levels during the last solar minimum. Aims. We aim to reveal the momentary variation of solar surface rotation, especially during the recent years of reducing solar activity. Methods. We used a dynamic, differentially rotating reference system to determine the best-fit annual values of the differential rotation parameters of active longitudes of solar X-ray flares and sunspots in 1977-2012. Results. The evolution of rotation of solar active longitudes obtained with X-ray flares and with sunspots is very similar. Both hemispheres speed up since the late 1990s, with the southern hemisphere rotating slightly faster than the north. Earlier, in 1980s, rotation in the northern hemisphere was considerably faster, but experienced a major decrease in the early 1990s. On the other hand, little change was found in the southern rotation during these decades. This led to a positive asymmetry in north-south rotation rate in the early part of the time interval studied. Conclusions. The rotation of both hemispheres has been speeding up at roughly the same rate since late 1990s, with the southern hemisphere rotating slightly faster than the north. This period coincides with the start of dramatic weakening of solar activity, as observed in sunspots and several other solar, interplanetary and geomagnetic parameters.

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Low-Mass and Substellar Abstracts

On The Structure and Evolution of Planets and Their Host Stars – Effects of Various Heating Mechanisms on The Size of Giant Gas Planets

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It is already stated in the previous studies that the radius of the giant planets is affected by stellar irradiation. The confirmed relation between radius and incident flux depends on planetary mass intervals. In this study, we show that there is a single relation between radius and irradiated energy per gram per second (l_{-}), for all mass intervals. There is an extra increase in radius of planets if l_{-} is higher than 1100 times energy received by the Earth ($l_{\oplus}$). This is likely due to dissociation of molecules. The tidal interaction as a heating mechanism is also considered and found that its maximum effect on the inflation of planets is about 15 per cent. We also compute age and heavy element abundances from the properties of host stars, given in the TEPCat catalogue (Southworth 2011). The metallicity given in the literature is as [Fe/H]. However, the most abundant element is oxygen, and there is a reverse relation between the observed abundances [Fe/H] and [O/Fe]. Therefore, we first compute [O/H] from [Fe/H] by using observed abundances, and then find heavy element abundance from [O/H]. We also develop a new method for age determination. Using the ages we find, we analyse variation of both radius and mass of the planets with respect to time, and estimate the initial mass of the planets from the relation we derive for the first time. According to our results, the highly irradiated gas giants lose 5 per cent of their mass in every 1 Gyr.

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Upcoming Meeting

Statistics and Exoplanets

2nd Announcement

3 - 5 August 2015

A Focus Meeting within the XXIX IAU General Assembly
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www.exostats.org

The discovery and characterization of exoplanets requires both superbly accurate instrumentation and sophisticated statistical methods. Weak or rare planetary signals must be extracted from dominant starlight, very large samples and noisy datasets. This meeting will bring together exoplanet and statistical experts to discuss and address key challenges in exoplanet detection (including radial velocity, astrometry, transits, direct imaging and microlensing), detailed planet characterization, and population studies.

The program will consist of invited talks by leading astronomers and statisticians at the forefront of exoplanet detection and characterization, contributed posters and talks, and discussion. A day of hands-on tutorial-style experimentation with key algorithms and software packages will follow the meeting. For more information, see the website www.exostats.org.

Interested scientists can register, submit abstracts, arrange lodging and logistics through the IAU General Assembly website (www.astronomy2015.org). Early registration is open until 1 Dec 2014 though registration continues through the meeting.

We look forward to a productive cross-disciplinary exchange of ideas on the methodology of exoplanetary discovery and science, and hope to see many of you there.

S. Aigrain & E. Feigelson on behalf of the SOC

This meeting is cosponsored by the International Statistical Institute, International Astrostatistics Association, Institute of Mathematical Statistics and the International Astronomical Union

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.***