COOLNEWS

A RESEARCH NEWSLETTER DEDICATED TO COOL STARS AND THE SUN

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Stellar Abstracts

Constraining a Model of Turbulent Coronal Heating for AU Microscopii with X-Ray, Radio, and Millimeter Observations

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Many low-mass pre-main-sequence stars exhibit strong magnetic activity and coronal X-ray emission. Even after the primordial accretion disk has been cleared out, the star's high-energy radiation continues to affect the formation and evolution of dust, planetesimals, and large planets. Young stars with debris disks are thus ideal environments for studying the earliest stages of non-accretion-driven coronae. In this paper we simulate the corona of AU Mic, a nearby active M dwarf with an edge-on debris disk. We apply a self-consistent model of coronal loop heating that was derived from numerical simulations of solar field-line tangling and magnetohydrodynamic turbulence. We also synthesize the modeled star's X-ray luminosity and thermal radio/millimeter continuum emission. A realistic set of parameter choices for AU Mic produces simulated observations that agree with all existing measurements and upper limits. This coronal model thus represents an alternative explanation for a recently discovered ALMA central emission peak that was suggested to be the result of an inner "asteroid belt" within 3 AU of the star. However, it is also possible that the central 1.3 mm peak is caused by a combination of active coronal emission and a bright inner source of dusty debris. Additional observations of this source's spatial extent and spectral energy distribution at millimeter and radio wavelengths will better constrain the relative contributions of the proposed mechanisms.

Accepted by ApJ

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For preprints via ftp or WWW: http://arXiv.org/abs/1306.4567

A Spectroscopic Analysis of the Eclipsing Short-Period Binary V505 Persei and the Origin of the Lithium Dip

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As a test of rotationally-induced mixing causing the well-known Li dip in older mid-F dwarfs in the local Galactic disk, we utilize high-resolution and -S/N Keck/HIRES spectroscopy to measure the Li abundance in the components of the ∼1 Gyr, [Fe/H]= −0.15 eclipsing short-period binary V505 Per. We find $A(\mathrm{Li}) \sim 2.7 \pm 0.1$ and 2.4 ± 0.2 in the T_{eff}∼6500 and 6450K primary and secondary components, respectively. Previous T_{eff} determinations and uncertainties suggest that each component is located in the midst of the Li dip. If so, their A(Li) are ≥2–5 times larger than A(Li) detections and upper limits observed in the similar metallicity and intermediate-age open clusters NGC 752 and 3680, as well as the more metal-rich and younger Hyades and Praesepe. These differences are even larger if the consistent estimates of the scaling of initial Li with metallicity inferred from nearby disk stars, open clusters, and recent Galactic chemical evolution models are correct. Our results suggest, independently of complementary evidence based on Li/Be ratios, Be/B ratios, and Li in subgiants evolving out of the Li dip, that main-sequence angular momentum evolution is the origin of the Li dip. Specifically, our stars' A(Li) indicates tidal synchronization can be sufficiently efficient and occur early enough in short-period binary mid-F stars to reduce the effects of rotationally-induced mixing and destruction of Li occuring during the main-sequence in otherwise similar stars that are not short-period tidally-locked binaries.

Accepted by PASP

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For preprints via ftp or WWW: http://arxiv.org/abs/1306.0644

Improved Angular Momentum Evolution Model for Solar-like Stars

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Understanding the origin and evolution of stellar angular momentum is one of the major challenges of stellar physics. We present new models for the rotational evolution of solar-like stars between 1 Myr and 10 Gyr with the aim of reproducing the distributions of rotational periods observed for star forming regions and young open clusters within this age range. The models include a new wind braking law based on recent numerical simulations of magnetized stellar winds and specific dynamo and mass-loss prescriptions are adopted to tie angular momentum loss to angular velocity. The models additionally assume constant angular velocity during the disk accretion phase and allow for decoupling between the radiative core and the convective envelope as soon as the former develops. We have developed rotational evolution models for slow, median, and fast rotators with initial periods of 10, 7, and 1.4d, respectively. The models reproduce reasonably well the rotational behavior of solar-type stars between 1 Myr and 4.5 Gyr, including pre-main sequence (PMS) to zero-age main sequence (ZAMS) spin up, prompt ZAMS spin down, and the early-main sequence (MS) convergence of surface rotation rates. We find the model parameters accounting for the slow and median rotators are very similar to each other, with a disk lifetime of 5 Myr and a core-envelope coupling timescale of 28-30 Myr. In contrast, fast rotators have both shorter disk lifetimes (2.5 Myr) and core-envelope coupling timescales (12 Myr). We show that a large amount of angular momentum is hidden in the radiative core for as long as 1 Gyr in these models and we discuss the implications for internal differential rotation and lithium depletion. We emphasize that these results are highly dependent on the adopted braking law. We also report a tentative correlation between the initial rotational period and disk lifetime, which suggests that protostellar spin down by massive disks in the embedded phase is at the origin of the initial dispersion of rotation rates in young stars. We conclude that this class of semi-empirical models successfully grasp the main trends of the rotational behavior of solar-type stars as they evolve and make specific predictions that may serve as a guide for further development.

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Effects of M Dwarf Magnetic Fields on Potentially Habitable Planets

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We investigate the effect of the magnetic fields of M dwarf (dM) stars on potentially habitable Earth-like planets. These fields can reduce the size of planetary magnetospheres to such an extent that a significant fraction of the planet's atmosphere may be exposed to erosion by the stellar wind. We used a sample of 15 active dM stars, for which surface magnetic-field maps were reconstructed, to determine the magnetic pressure at the planet orbit and hence the *largest* size of its magnetosphere, which would only be decreased by considering the stellar wind. Our method provides a fast means to assess which planets are most affected by the stellar magnetic field, which can be used as a first study to be followed by more sophisticated models. We show that hypothetical Earth-like planets with similar terrestrial magnetisation (~ 1 G) orbiting at the inner (outer) edge of the habitable zone of these stars would present magnetospheres that extend at most up to 6 (11.7) planetary radii. To be able to sustain an Earth-sized magnetosphere, with the exception of only a few cases, the terrestrial planet would either (1) need to orbit significantly farther out than the traditional limits of the habitable zone; or else, (2) if it were orbiting within the habitable zone, it would require at least a magnetic field ranging from a few G to up to a few thousand G. By assuming a magnetospheric size that is more appropriate for the young-Earth (3.4 Gyr ago), the required planetary magnetic fields are one order of magnitude weaker. However, in this case, the polar-cap area of the planet, which is unprotected from transport of particles to/from interplanetary space, is twice as large. At present, we do not know how small the smallest area of the planetary surface is that could be exposed and would still not affect the potential for formation and development of life in a planet. As the star becomes older and, therefore, its rotation rate and magnetic field reduce, the interplanetary magnetic pressure decreases and the magnetosphere of planets probably expands. Using an empirically derived rotation-activity/magnetism relation, we provide an analytical expression for estimating the shortest stellar rotation period for which an Earth-analogue in the habitable zone could sustain an Earth-sized magnetosphere. We find that the required rotation rate of the early- and mid-dM stars (with periods $> 37 - 202$ days) is slower than the solar one, and even slower for the late-dM stars ($> 63 - 263$ days). Planets orbiting in the habitable zone of dM stars that rotate faster than this have smaller magnetospheric sizes than that of the Earth magnetosphere. Because many late-dM stars are fast rotators, conditions for terrestrial planets to harbour Earth-sized magnetospheres are more easily achieved for planets orbiting slowly rotating early- and mid-dM stars.

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For preprints via ftp or WWW: http://arxiv.org/pdf/1306.4789v2.pdf

The Decaying Long-period Oscillation of a Stellar Megaflare

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We analyse and interpret the oscillatory signal in the decay phase of the U-band light curve of a stellar megaflare observed on 2009 January 16 on the dM4.5e star YZ CMi. The oscillation is well approximated by an exponentially decaying harmonic function. The period of the oscillation is found to be 32 min, the decay time about 46 min and the relative amplitude 15%. This observational signature is typical of the longitudinal oscillations observed in solar flares at EUV and radio wavelengths, associated with standing slow magnetoacoustic waves, suggesting a similar nature. In

this scenario, macroscopic variations of the plasma parameters in the oscillations modulate the ejection of non-thermal electrons. The phase speed of the longitudinal (slow magnetoacoustic) waves in the flaring loop or arcade, the tube speed, of about 230 km/s, would require a loop length of about 200 Mm. Other mechanisms, such as standing kink oscillations, are also considered.

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Solar Abstracts

Occurrence Probability of Large Solar Energetic Particle Events: Assessment from Data on Cosmogenic Radionuclides in Lunar Rocks

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We revisited assessments of the occurrence probability distribution of large events in solar energetic particles (SEP), based on measurements of cosmogenic radionuclides in lunar rocks. We present a combined cumulative occurrence probability distribution of SEP events based on three timescales: directly measured SEP fluences for the past 60 years; estimates based on the terrestrial cosmogenic radionuclides ^{10}Be and ^{14}C for the multi-millennial (Holocene) timescale; and cosmogenic radionuclides measured in lunar rocks on a timescale of up to 1 Myr. These three timescales yield a consistent distribution. The data suggest a strong roll-over of the occurrence probability, so that SEP events with a proton fluence with energy > 30 MeV greater than 10^{11} (protons cm^{-2} yr^{-1}) are not expected on a Myr timescale.

Accepted by Solar Physics (in press) *For preprints contact*: ilya.usoskin@oulu.fi

Upcoming Meeting

Magnetic Fields Throughout Stellar Evolution (IAUS 302)

25 - 30 August 2013

Biarritz, France

The program of IAUS 302 is now available online at

http://iaus302.sciencesconf.org/program

The full list of abstracts (including posters) can be found here:

http://iaus302.sciencesconf.org/browse/session

The deadline for registration is on July 21! To join us in Biarritz at the end of August, we invite you to proceed to the registration page:

http://iaus302.sciencesconf.org/registration/index

The SOC and LOC of IAUS 302.

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.***