SPD Thomas Metcalf Travel Award Report

COFFIES Annual Meeting 2026

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Dr. Vindya Vashishth

Vindya is a Ph.D. graduate from Indian Institute of Technology (BHU), Varanasi, India, and conducted her doctoral research under the guidance of Dr. Bidya Binay Karak. Her research focuses on the Mean-Field Dynamo theory and its applications to the Sun and other solar-type stars. Her research contributes to the current understanding of the stellar magnetic activity by developing comprehensive dynamo models to explain observed trends in magnetic cycles, variability, and grand minima across stars with different rotation rates.

Invited Talk on "Understanding the variabilities of solar-type stars using dynamo modeling"

Vindya Vashishth, Bidya Binay Karak and Leonid Kitchatinov

Stellar magnetic cycles exhibit irregularities, with stars of rapid rotation showing stronger and irregular magnetic activity compared to slow rotators. Some stars also experience extended grand minima, similar to the Maunder minimum observed in the Sun. Since rotation strongly influences these phenomena, the primary goal of my work is to make detailed dynamo models for stars with different rotation rates and explain these observational trends of the magnetic activity as a function of their rotation. In my work, I use the 3D STABLE (Surface flux Transport And Babcock–Leighton) dynamo model to highlight the connection of the flow speed, field strength, and cycle duration with stellar rotation.

We find that the magnetic field strength initially increases with the stellar rotation rate and then declines in rapidly rotating stars, explaining the observed saturation of magnetic activity in rapidly rotating stars. My work also focuses on the possibility of the operation of the Babcock–Leighton dynamo in rapidly rotating stars where starspots appear in the high latitudes (Figure 1).

One of the major questions that I address by using extensive simulations of the kinematic flux transport dynamo model with stochastically forced Babcock–Leighton source for the stars of one solar mass with different rotation periods, is how the stellar cycle variability and grand minima depend on stellar rotation rate. My study confirms that the rapidly rotating stars exhibit more irregular and stronger magnetic activity than slower rotators, with fewer occurrences of grand minima. Grand minima are predominantly observed in slowly rotating stars, with their frequency and duration increasing as a star spins down (Figure 2). The results align closely with observations of the Sun and other solar-like stars.

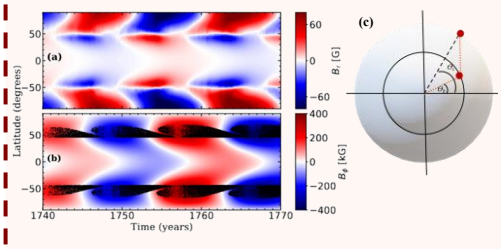
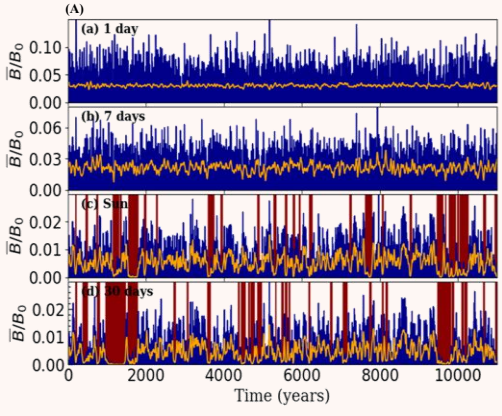


Figure 1: Time–latitude distribution of the (a) surface radial magnetic field (in kG), and (b) toroidal field along with star-spot distribution (black dots) for a star of 1-d rotation period based on the Star-spot placement as described in (c).
Ref: Vashishth & Karak 2026



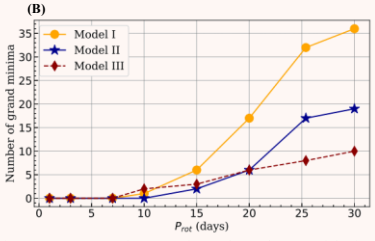


Figure 2: (A) Time series plot along with its smoothed variation of toroidal magnetic field of stars having different rotation periods. The dark-red bars highlight the extended weaker activity episodes i.e., grand minima in each case. (B) Increasing trend of the number of grand minima with the rotation period of stars.
Ref: Vashishth et. al. 2023.

Being selected for the Thomas Metcalf Award was a true honor and gave me with the opportunity to present my work as a Metcalf Lecturer. I am grateful to the AAS/SPD Thomas Metcalf Travel Award committee and the organizers of the COFFIES Annual Meeting 2026 for selecting me for this prestigious award. Attending the meeting was truly inspiring. I had the chance to learn directly from the researchers whose work I have read, cited, and admired for years, and discussed how my research can help improve current models of solar and stellar magnetic activity. I also received valuable feedback and suggestions that will undoubtedly enhance the quality of my work. As an early-career researcher, these interactions are incredibly valuable for shaping my future research and building meaningful collaborations. In addition to the scientific discussions, the interdisciplinary workshop on the first day helped me grow my team-building and communication skills.