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Subcritical dynamo and hysteresis in a Babcock-Leighton type kinematic dynamo model

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A large-scale magnetic cycle is possible in the Sun and other stars as long as the large-scale shear and helicity of the plasma flow in their convection zones are sufficiently strong. Hence, there is a critical dynamo number for each star for the operation of a large-scale dynamo. As a star spins down, it is expected that the large-scale dynamo ceases to operate above a critical rotation period. Our study explores the possibility of the operation of the dynamo in the subcritical region using the Babcock-Leighton type kinematic dynamo model. In some parameter regimes, we find that the dynamo shows hysteresis behavior, i.e., two dynamo solutions are possible depending on the initial parameters—decaying solution if started with weak field and strong oscillatory solution (subcritical dynamo) when started with a strong field. However, under large fluctuations in the dynamo parameter, the subcritical dynamo mode is unstable in some parameter regimes. Therefore, our study supports the possible existence of subcritical dynamo in some stars which was previously shown in a mean-field dynamo model with distributed α and MHD turbulent dynamo simulations.

Primary author: VASHISHTH, Vindya (Indian Institute of Technology, Varanasi)

Co-authors: KARAK, Bidya Binay (Indian Institute of Technology (BHU) Varanasi); Prof. KITCHATINOV, Leonid (Institute of Solar-Terrestrial Physics SB RAS)

Presenter: VASHISHTH, Vindya (Indian Institute of Technology, Varanasi)

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