Project Details

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Topic: The Solar-Stellar Connection

Project Title:
Evolving Models of Stellar Photospheric and Coronal Magnetic Fields

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Summary:
Magnetic fields in the atmospheres of Sun-like stars are the bridge between the dynamo activity occurring in stellar interiors and their observable characteristics. Observational evidence of magnetic fields and magnetic proxies show that Sun-like stars span the gamut of activity levels, ranging from extremely quiet stars to highly variable stars possessing starspots or starspot groups covering a large fraction of the stellar surface. Furthermore, comparative studies show the Sun is far from a typical star.

In this project, we aim to answer the following science questions:

, What constraints can measurements of magnetic spots, differential rotation, and flares on other stars teach us about the solar dynamo?

, What are the limits of observational inference of magnetic fields and differential rotation on other stars?

, What are the coronal magnetic configurations associated with superflare events (as observed, for example, in white light photometric data in Kepler)?

, What is the importance of well-known physical processes on the Sun (including flux emergence, differential rotation, turbulent diffusion) for magnetic activity on other stars?

We propose a forward modeling framework to address these questions. First, we will run a series of surface-flux transport (SFT) models of starspot evolution. A number of these models will then be used as lower boundary conditions to drive time-evolving force- free models of the global stellar coronal field. The coronal magnetic fields are evolved by magnetofriction (MF), which has been applied successfully for modeling a variety of solar coronal field configurations, including active regions and filaments. This type of time-dependent modeling will allow us to construct force-free coronal fields evolving in response to starspot evolution.

The combined SFT/MF simulations will be used to produce synthetic spectropolarimetric measurements, which then will serve as input constraints for Zeeman Doppler Imaging (ZDI) inversions. The aim is to determine the validity of the inversions, and to examine the correspondence between such inferred magnetic properties with the input SFT parameters governing flux emergence, differential rotation and turbulent dispersal. Properties that appear important for the solar case but are not well constrained for other stars, such as latitudinal flows, will also be considered. The buildup of free magnetic energy in the MF simulation domain will also be evaluated, and used to determine whether evolution associated with interacting starspots (which

presumably may be much larger than the biggest sunspots) may build up sufficient free magnetic energy to power so-called superflares (such as those observed in Kepler white light time series data).

This project is expected to complement other participating projects in the LWS Solar- Stellar Connection Focus Team by enabling outputs of dynamo models, in particular those that produce time-varying surface flux patterns throughout successive stellar activity cycles, to be used for ZDI inversions and coronal MF simulations described above. The resulting Stokes spectral profiles and model coronal fields can then be analyzed as if they were observed, and compared with actual observations of cool stars. ,

Publication References:

no references