

Ages of Young Stars and the Evolution of Dynamo-Generated Magnetic Fields

Stars with masses below 5 solar masses begin their lives

Purpose and Aims

Survey of the Field

- Age-dating problems for young stars. (i.e., model inconsistencies)
- Identification / inclusion of magnetic fields in models. (D'Antona, MacDonald, Feiden)
- Magnetic field observations. (e.g., MDI, ZDI)
- Open questions.

Project Description

P1. Dynamo-Generated Magnetic Fields throughout Early (sub)Stellar Evolution Trace the temporal evolution of dynamo-generated magnetic fields. Explore how these properties depend on rotation, convection zone size, and stellar fundamental properties (surface temperature). Investigate the (1) topology of large-scale magnetic fields as a function of stellar mass, chemical composition, and age; (2) role of interior magnetic fields in governing stellar structure; and (3) the evolution of stellar activity cycles through polarity reversals of the large-scale field.

P1.1 Magnetic Fields in Surface Convection Zones of Low- and Intermediate-Mass Stars

Straight 2D/3D models allow one to explore field properties as a function of stellar properties, but one loses temporal information. Strong magnetic fields are able to inhibit convective motions and delay contraction of young, pre-main-sequence stars. This means stellar rotation periods and convection zone sizes (core and surface) as a function of age differ between for stars with strong magnetic fields and those without. To model the feedback of the magnetic field on stellar properties over stellar evolutionary timescales (hundreds of thousands of years), simpler 1D stellar structure models are necessary.

P1.2 Core Convection in the Presence of Magnetic Fields

P1.3 Magnetic Fields in Young Brown Dwarfs and Giant Planets

Investigating the generation and impact of magnetic fields in cool, high density plasmas. Finite electrical conductivity becomes a significant factor. Seek to answer: Is the contraction time of young brown dwarfs and giant planets affected by magnetic fields?

Magnetic Inhibition of Convection, Starspots, and Atmospheric Properties

Improved treatment of surface boundary conditions through incorporation of detailed frequency-dependent radiative transfer. Seek to answer: How are surface boundary conditions affected by magnetic inhibition of convection, and how do they affect interior structure? How do starspots affect observational properties of young stars?

Homogeneous Ages for Young Stellar Associations

Significance

Young stellar ages → protoplanetary disk evolution timescale thus giant planet formation timescale; star formation history, including mass distribution (IMF); mass distribution of directly imaged planets / brown dwarfs.

Preliminary Results

Feiden (2016, submitted).

Pilot study showing results for the Sun (and a low-mass star?).

Independent Line of Research**International and National Collaborations**

Observational Campaigns:

- Kraus, Rizzuto, Mann (UT Austin) — B- through M-type EBs in young associations with K2 & magnetic fields of young stars with IGRINS.
- Kochukhov (Uppsala), Hussain (ESO) — magnetic field topologies (MDI/ZDI) of young stars.

Other Grants