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Dynamo models and differential rotation in the Sun and other late-type stars

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Dynamo models and differential rotation in the Sun and other late-type stars

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In the last decade or so, analyses of helioseismic data have produced reliable determinations of the spatial variation of the mean rotation law within the solar convection zone, and have also revealed significant temporal variations of this differential rotation. In particular, the cyclic fluctuations in angular velocity seen at the surface ('torsional oscillations') are found to persist through a substantial part of the convection zone, although their resolution becomes increasingly difficult as depth increases. Given these inevitable difficulties in resolving the precise nature of the variations in deeper layers, theoretical investigations of expected modes of behaviour, using nonlinear dynamo models, are essential.

We report on the results of our recent detailed studies of the variations in the differential rotation in the solar convection zone using nonlinear dynamo models which include the action of the Lorentz force of the dynamo generated magnetic field on the angular velocity. These studies predicted significant features of the angular velocity variations in the solar convection zone, including

- the robust existence of torsional oscillations that penetrated all the way down to the bottom of the convection zone for near-critical and moderately supercritical dynamo regimes with the observed magnitude [**?**, **?**, **?**];
- the existence of parameter ranges for which the models show spatiotemporal bifurcations, resulting for example in different periods of variation of the angular velocity at the top and bottom of the convection zone [**?**, **?**, **?**];
- the robust presence of polar and equatorial branches in the angular velocity residuals, propagating from mid-latitudes towards the poles and the equator [**?**, **?**, **?**].

Importantly these predictions have been substantiated by the most recent inversions (see e.g. [**?**]).

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