The Evolution of Weak Magnetic Fields of the Sun in Relation to Dynamo Theory

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We present here a model to explain how the weak large-scale diffuse magnetic fields of the sun migrate poleward in contrast to the sunspots which migrate equatorward with the progress of the solar cycle. We study the evolution of the sun's poloidal field in the convection zone by assuming that it is produced by an equatorward-propagating dynamo wave at the base (Choudhuri 1990, Astr. J., 355, 733) of the convection zone and is subject to turbulent diffusion and a meridional circulation with a poleward surface flow. The magnetic fieldiness in the lower part of the convection zone first move towards the equator where they are pushed upward by the upwelling meridional flow there to form magnetic bubbles by joining with their opposite hemisphere counterparts. After reaching the surface, these bubbles drift to higher latitudes with the poleward meridional flow. Our model incorporates the three-dimensional vector character of the magnetic field, whereas the previous model of Wang et al. for the poleward drift of weak fields treated the magnetic field as a scalar on the two-dimensional solar surface.

Magneto-Convection in Sunspot Penumbra

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The original motivation for studying the magneto-convection arose from the attempts to explain the origin of sunspots. Here we analyze the effect of horizontal magnetic field on Rayleigh-Bénard convection in a region where

$$\frac{k}{\eta} = \frac{\sigma_2}{\sigma_1} < 1 \text{ for any } Q,$$

and

$$\frac{k}{\eta} = \frac{\sigma_2}{\sigma_1} > 1 \text{ for } Q < Q_c = \frac{(1 + \sigma_1)(\pi^2 + q_c^2)^2}{q_c^2(\sigma_2 - \sigma_1)}$$