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Modeling of the solar interface dynamo

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The cycle of magnetic activity of the Sun is usually associated with the action of dynamo mechanism. We investigated the $\alpha\Omega$-dynamo model with suggestion that action of α-effect dominates in one layer and differential rotations action in another. The scheme was proposed by Parker in 1993.

$$\frac{\partial B}{\partial t} = \beta \Delta B; \quad \frac{\partial A}{\partial t} = \alpha B + \beta \Delta A; \quad \frac{\partial b}{\partial t} = D \cos\theta \frac{\partial a}{\partial \theta} + \Delta b; \quad \frac{\partial a}{\partial t} = \Delta a;$$

$B(r, \theta, t), b(r, \theta, t)-$ is the toroidal magnetic field produced from the poloidal field by the action of differential rotation in corresponding layer. Poloidal field in layers represented by toroidal component of vectorial potential $A(r, \theta, t), a(r, \theta, t)$The inverse process of transforming toroidal magnetic field into poloidal field occurs by the α -effect, arising from convection in the rotating body. β- is the ratio of the diffusion coefficients in the first and second layers. The equations are linked by means of boundary conditions. We develop a WKB method for the asymptotic solution of the corresponding dynamo equations. A Hamilton–Jacobi equation (or dispersion relation), algebraic with respect to the wave vector of the dynamo wave that is excited, is obtained. Hamilton–Jacobi equation obtained shows a way to pursue asymptotical investigations of the solar interface dynamo. We demonstrate that crucially properties of the solution are determined by the turbulent diffusivity contrast β in the shells. If$\beta = 1$ the solution can be reduced to a solution of one-shell Parker migratory dynamo. Varying β allows for the adjustment of the imaginary part of the growth rate, leading to longer cycles than that of the Parker migratory dynamo. We also included the meridional circulation of substance in the model to consider the return of substance after spreading from equator to poles. The duration of solar cycle increases with both growing of intensity of meridional circulation in two layers and contrast of intensity growing in layers. Minimum of magnetic activity is possible not only in case high intensity of meridional circulation in both layers but when there is a difference between physical properties in the layers and meridional flows are moderate.