NEW MECHANISM OF GENERATION OF LARGE-SCALE MAGNETIC FIELD IN TURBULENCE WITH AN IMPOSED MEAN VELOCITY SHEAR

I. Rogachevskii, N. Kleeorin, and E. Liverts

Department of Mechanical Engineering, Ben-Gurion University of Negev, POB 653, 84105 Beer-Sheva, Israel

The nonlinear theory of a "shear-current" effect in a nonhelical turbulence with an imposed mean velocity shear is discussed. The "shear-current" effect is associated with the $\mathbf{W}\times\mathbf{J}$-term in the mean electromotive force and causes the generation of the large-scale magnetic field even in a nonrotating and nonhelical homogeneous turbulence (where $\mathbf{W}$ is the mean vorticity due to the large-scale shear motions and $\mathbf{J}$ is the mean electric current). We found that there is no quenching of the nonlinear shear-current effect contrary to the quenching of the nonlinear alpha effect, the nonlinear turbulent magnetic diffusion, etc. During the nonlinear growth of the mean magnetic field, the shear-current effect only changes its sign at some value of the mean magnetic field which determines the level of the saturated mean magnetic field. The magnetic helicity transport as a dynamical nonlinearity is also taken into account. We demonstrated that the inclusion of the helicity flux in the magnetic helicity balance in the nonlinear stage of the dynamo action results in a radical change in the magnetic field dynamics. The saturated level of the mean magnetic field is of the order of the equipartition field determined by the turbulent kinetic energy. This is in contrast to the situation without the flux of helicity, when the magnetic helicity is conserved locally, which leads to substantially subequipartition values for the equilibrium large-scale magnetic field. The developed theory is applied for explanation of the generation of large-scale magnetic fields in colliding protogalactic clouds and merging protostellar clouds. Interaction of the colliding clouds produces large-scale shear motions which are superimposed on small-scale turbulence. The estimated large-scale magnetic field for merging protogalactic clouds is about several microgauss, and for merging protostellar clouds is of the order of several tenth of microgauss.