Periodic imbalances of kinetic and magnetic energies in rotating magnetohydrodynamic turbulent flows

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A significant number of observed flows in geophysics, astrophysics, and laboratory experiments are in a state of magnetohydrodynamic turbulence. Among them are flows in the Earth's outer core, in plasma shells of Earth, planets, and satellites of the solar system with strong magnetic fields, as well as flows in the Sun, stars, and astrophysical disks. Despite significant advances in the study of turbulence under the conditions typical of thermonuclear fusion devices, studies of the fundamental properties of homogeneous turbulence in rotating magnetohydrodynamic flows are still fragmentary and mainly concern turbulence in astrophysical disks, the solar tachocline and convective region of the Sun, and two-dimensional magnetohydrodynamic flows on the β-plane. Only in a few exceptional works were the properties of magnetohydrodynamic turbulence studied by simple analytical methods using Fourier series for similarity parameters, characteristic of the Earth's core.

The aim of this work is to study the influence of the interaction of Alfvén wave packets on the dynamics of homogeneous turbulence. The method of calculation of magnetohydrodynamic turbulence we developed allows numerical simulation at large characteristic times and large external magnetic fields. The proposed method of setting the initial conditions for the velocity field makes it possible to satisfy the divergence-free, homogeneity, and turbulence isotropy conditions, as well as to set an arbitrary spectral distribution of the energy at the initial time without additional calculations. Numerical experiments demonstrate a nontrivial behavior of turbulent kinetic and magnetic energies. It is shown that periodic imbalance in energies occurs in the system in the form of conversion of kinetic energy into magnetic energy and vice versa. The analysis of the results shows that the detected nontrivial temporal dynamics of turbulence is caused by the periodic collisions of Alfvén wave packets.

This work was supported by the Russian Foundation for Basic Research (project no. 19-02-00016).
