Turbulent Dynamo as Spontaneous Symmetry Breaking: Two-Loop Approximation

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Abstract

The study of developed turbulence in electrically conducting fluid driven by the stochastic Navier-Stokes equation has been a subject of intense study [1, 2, 3]. A special role in this regime is played by the properties of the system associated with fluctuations in the magnetic field. In particular, they hold pivotal importance in comprehending diverse convective processes, astrophysics, and cosmology, particularly in elucidating the genesis and progression of large-scale cosmic magnetic fields through the so-called turbulent dynamo mechanism. This effect is most conspicuous in chiral (gyrotropic) fluids, characterized by parity violation, and is intricately linked to the conservation of magnetic helicity. Our research uses field-theoretic methods to propose a general scenario for the generation and renormalization of arising homogeneous magnetic field. We delve into a quantum-field model of stochastic MHD [4, 5], specifically exploring mirror symmetry. Emphasis is placed on analyzing the stability of this system, which is attributed to the emergence of a non-vanishing average large-scale homogeneous magnetic field. In order to clarify the previously obtained one-loop results [5] for the value of spontaneous magnetic field and deformation of Alfvén waves we use two-loop calculations. These complex two-loop calculations are necessary for a self-consistent conclusion that the mechanism of system stabilization (turbulent dynamo) is not destroyed by the influence of higher orders of perturbation theory.

References

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