Two-dimensional models in magnetohydrodynamics and dynamo theory

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Abstract

Nowadays most of the problems in magnetohydrodynamics are solved using direct numerical simulation methods. Such approaches give proper results and allow us to describe a wide range of effects. However, sometimes they do not give us an opportunity to understand the principal dependences between between different parameters and to study the qualitative mechanisms. Also sometimes even modern computational resources are not enough to solve the equations using detailed grids. So the two-dimensional models become very actual. They give us possibilities both to construct asymptotic solutions and to solve the equations numerically using quite limited computational resources.

In the presented work, there is a group of two-dimensional models, which are used to study magnetic fields in different astrophysical objects, such as spiral galaxies, outer rings of galaxies and accretion discs. Also the two-dimensional models which describe the magnetohydrodynamical processes in liquid metals under the action of electric current are presented, too.

The special interest is connected with so-called no-z approximation, which describes the field generation in discs of spiral galaxies. In the linear case the eigenvalue problem has been solved, and there is a spectral decomposition of the solution, for which the eigenfunctions of the corresponding differential operators are used. It is shown that in spite of popular point of view, the non-axisymmetric solutions cannot take place in most of the realistic cases. For the nonlinear case the stationary points of the problem have been studied, also the type of stability is described. It is shown that we can have the contrast structures, which correspond to the magnetic field reversals in galaxies. The asymptotic solution for this case was constructed using singularity perturbations theory.