Antonym Expansion in the Kinetic and Hydrodynamic in Plasma Type

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Abstract

Characteristic examples of continuous symmetries in hydrodynamic plasma theory(partial differential equations) and in Kinetic Vlasov-Maxwell models (Integra differential equations) are considered. possible Symmetry extension ions conditional and extended symmetries are Discussed. physics reasons for these symmetry extensions are clarified

1 Introduction

Symmetry considerations essentially help us to solve nonlinear problems of plasma physics. Among the recent publications, a survey of methods which allow us to find symmetries of integro-differential equations of kinetic plasma theory [1] and a review of applications of symmetry methods to the hydrodynamic plasma models based on the partial differential equations [2] can be cited.

In the present paper, some characteristic examples of the symmetries are presented for various plasma theory models: electron magnetohydrodynamics, collisionless electron plasma oscillations, drift waves in plasma and multi-component collisionless plasma containing particles with equal charge to mass ratios.

In Section 2, Lie point symmetries are obtained for the partial differential equations of the electron magnetohydrodynamics by means of the standard Maple 11 program. A simple invariant solution is presented, which is in fact a background solution of a perturbation theory formalism. An additional condition is underlined which can lead to the symmetry extension.In Section 3, continuous symmetries of the integro-differential kinetic equations of the collisionless electron plasma model are discussed. The symmetries were found in [3] by an indirect algorithm which allows us to obtain symmetries of the kinetic equations from the symmetries of an infinite set of partial differential equations for the moments of distribution functions.

In Section 4, some conditional symmetries are presented for the Hasegawa–Mima hydrodynamic model describing drift waves in a plasma. Due to these symmetries, invariant solutions are possible describing the asymptotic structure of the nonlinear waves.In Section 5, additional symmetries for integro-differential equations of the kinetic theory of collisionless plasma containing particles with equal charge to mass ratio are considered. For example, alpha particles and deuterium ions participating in a thermonuclear reaction $D^+ + T^+ \rightarrow He^{++} + n + 17.6$ MeV have close charge to mass ratios. By simple vector considerations

2 Electron magnetohydrodynamics

Let us consider the equations of the electron magnetohydrodynamics (EMHD) [4]:

$$\frac{\partial \Psi}{\partial t} = \nabla \times (v \times \Psi), \qquad \Psi = B - \Delta B, \qquad v = -\nabla \times B, \qquad \nabla \cdot B = 0,$$