TENSORS AND KINETIC EQUATIONS FOR COLLECTIVE SELF-CONSISTENT MOTION OF ELECTRIC CHARGES

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This report presents the construction of tensors and the system of deterministic kinetic equations of collective self-consistent motion of free electric charges, designed for the purpose of modeling of self-organization and turbulence of plasma. In the absence of external electromagnetic field (EMF) self-organized motion of charges is determined by their collective interaction with each other through their own electromagnetic fields. Using four-dimensional representation of the EMF source in the form of the 4-current density , with the help of its four-dimensional differentiation, a second rank tensor  is obtained. Tensor’s components describe the dynamics of charges motion in three-dimensional space. For the sake of simplicity, movement of charges in vacuum is considered. The tensor  can be represented as the sum of symmetric and antisymmetric tensors. From these tensors, by differentiation with subsequent coagulation, self-consistent equations of charges motion are obtained. Equations of motion follow from tensor :

  (1)  (2)  (3)  (4)

where ρ and J = ρ**V** are electric charge and current density, respectively, c is the speed of light, **V** is charges velocity; t is time; ∂ is partial derivative symbol. Equations (1) and (2) are the canonical wave equations for charge density and current density. Equations (3) and (4) are continuity equations of current density. Equations of charges motion follow from symmetric and antisymmetric tensors respectively:

 (5)  (6)

 (7)  (8)

It is noteworthy that equation (6) is the electromagnetic analogue of the well-known Lame equation of motion of an isotropic elastic medium, describing mechanical waves propagation. Therefore, it can be considered as the wave equation for current density and be recorded in non-homogeneous form:. In this equation the source of waves of current density is time-varying density gradient of charges. It is the description of vortex wave collective motion of free charges, which can be considered as waves of plasma turbulence. Equation (4) implies the possibility of formation of stationary current vortex structures described by the equation:

. Mass of charge is not included into 4-current density expression, therefore, all the above equations are complemented by mass equations. The resulting system of equations can be used to model the hydrodynamics of plasma and MHD instabilities.