Author: Hamid Saleem

Title: "Exact analytical solutions of two fluid plasma equations for the generation of longitudinally uniform jet-like flows and magnetic fields by baro clinic vectors"

Abstract:

Biermann battery effect has been revisited to include the role of ions in the generation of magnetic (B) and flow (V) fields in the classical plasma. It is shown that if the plasma flow is assumed to be longitudinally uniform, then exact analytical solutions of the set of two fluid partial differential equations exist in Cartesian and cylindrical geometries. The set of highly nonlinear partial differential equations reduces to two simple linear equations with baroclinic vectors of electrons and ions as source terms for the coupled flow and magnetic fields. Thus ions cannot be assumed to be static in the process of magnetic field generation. Particular profiles of density and temperatures of both species in nonequilibrium state of plasma, solve the two fluid equations exactly. In cylindrical geometry the jet-like plasma flow is created only in the perpendicular (axial) direction to the plasma disk while the magnetic field is produced in radial and theta directions. Weaknesses and inconsistent approximations used in electron magnetohydrodynamics (EMHD) are pointed out. It is shown that jet-like longitudinally uniform flows can also be created in neutral fluids by the density and temperature gradients.

6. **List of related published papers (option)**

- "Exact solution of partial differential equations for the creation of jet-like flows in plasmas and neutral fluids", H. Saleem, Phys. Plasmas 28, 044503 (2021).

- "Nonequilibrium two-fluid plasmas can generate magnetic fields and flows simultaneously" , H. Saleem, Phys. Plasmas 17, 092102 (2010).

- "Theory of cosmological seed magnetic fields", Phys. Plasmas 14, 072105 (2007).

- "Beltrami-like fields created by baroclinic effect in two fluid plasmas", H. Saleem and Z. Yoshida, Phys. Plasmas 11, 4865 (2004).