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Causal and Stable Magnetohydrodynamics

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We derive the equations of motion of relativistic magnetohydrodynamics from the Boltzmann equation using the method of moments. We generalize the references [1, 2] and consider a fluid to be a locally neutral system composed of a particle with opposite charges, with vanishing dipole moment or spin, so that the fluid has vanishing magnetization and polarization.

We demonstrate that the magnetohydrodynamical equations of motion become dramatically different for this more realistic system. The shear stress tensor no longer obeys a single differential equation: it breaks into three non-degenerate components with respect to the magnetic field each evolving according to different dynamical equation. For large magnetic fields we further show that the solutions of this theory display oscillatory behaviour that can no longer be described by an Israel-Stewart-like theory. Finally, we investigate the derived equations in a Bjorken flow scenario.

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[1] Denicol, Gabriel & Molnár, Etele & Niemi, Harri & Rischke, Dirk. (2019). Physical Review D. 99. 10.1103/PhysRevD.99.056017. DOI: 10.1103/PhysRevD.99.056017

[2] Denicol, Gabriel & Huang, Xu-Guang & Molnár, Etele & Monteiro, Gustavo & Niemi, Harri & Noronha, Jorge & Rischke, Dirk & Wang, Qun. (2018). Physical Review D. 98. 10.1103/PhysRevD.98.076009. DOI: 10.1103/PhysRevD.98.076009

Category

Theory

Collaboration (if applicable)

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