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Stability and Causality of the relativistic third order hydrodynamics

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The hot and dense QCD medium created in relativistic heavy ion collisions behaves like a fluid system and successfully studied by tools of relativistic hydrodynamics. A theory of relativistic hydrodynamics should be causal and stable. Causality is the restriction imposed by special theory relativity which doesn't allow any information to travel faster than the speed of light. The earliest formulations of relativistic hydrodynamic equations for non-ideal fluids were covariant generalisations of the Navier-Stokes equations of Newtonian non-perfect fluids by Eckart [1] and Landau-Lifshitz [2]. These are first-order theories which involve parabolic differential equations and violate causality and face instability problem. The parabolic character is responsible for the thermodynamic fluxes to react instantaneously to the corresponding thermodynamic forces which leads to the infinite speed of propagation of disturbances.

The attempts to get rid of the acausality and remove the instability of first-order hydrodynamics and to obtain a hyperbolic second-order theory led to the derivation of Israel-Stewart equations. In this generalised theory, dissipative fluxes such as heat flux, shear and bulk stresses are treated as independent variables and their evolution equations are hyperbolic in nature. The second-order theories allows the existence of a relaxation time for dissipative processes so the system doesn't returns to the equilibrium states instantaneously unlike Navier-Stokes theory, which restore causality. Hiscock and Lindblom later showed that the perturbations in the medium evolve causally and do not cause any instability in Israel-Stewart theory around equilibrium states [3].

Despite the success of Israel-Stewart theory in explaining a wide range of collective phenomena observed in heavy-ion collisions, it has resulted in unphysical effects such as reheating of the expanding medium [4] and negative longitudinal pressure [5]. This motivates the improvisation of the relativistic second-order theory by incorporating higher-order corrections. In Ref. [6] a new relativistic third-order evolution equation for the shear stress tensor from kinetic theory is derived. We will be presenting the analysis of the causality and stability properties of the third-order relativistic hydrodynamics and some interesting results about the dispersion relation and group velocity of modes of propagation of disturbances.

References

1. C. Eckart, Phys. Rev.58, 267 (1940).
2. L. D. Landau and E.M. Lifshitz,Fluid Mechan-ics(Butterworth-Heinemann, Oxford, 1987)
3. W. A. Hiscock and L. Lindblom, Annals Phys.151,466 (1983). doi:10.1016/0003-4916(83)90288-9.
4. A. Muronga, Phys. Rev. C69, 034903 (2004).
5. M. Martinez and M. Strickland, Phys. Rev. C79,044903 (2009).
6. A. Jaiswal, Phys. Rev. C88, 021903(R) (20013).

Primary authors: Mr SEBASTIAN, Jobin (School of Physical Sciences, National Institute of Science Education and Research, HBNI, Jatni-752050, India.); Dr JAISWAL, Amaresh (School of Physical Sciences, National Institute of Science Education and Research, HBNI, Jatni-752050, India.)

Presenter: Mr SEBASTIAN, Jobin (School of Physical Sciences, National Institute of Science Education and Research, HBNI, Jatni-752050, India.)

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