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Non-linear causality in Israel-Stewart like fluid theories

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Israel-Stewart like theories (IS) describe relativistic viscous fluids that obey first order partial differential equations in its variables, being appealing theories from a numerical-modeling point of view. Furthermore, the IS theory is one of a few theories that has been proven to be causal and stable after small perturbations around equilibrium, both in the linear regime. After the detection of the quark-gluon plasma (QGP) in the 2000's (whose formation occurs in ultra-relativistic heavy-ion collisions resulting in a liquid behavior of the quarks, anti-quarks, and gluons that move independently in such high energy conditions), IS like theories have been widely used with great success to describe this kind of plasma. However, when dealing with a relativistic theory, nonlinear causality is essential, especially within far from equilibrium situations like the QGP. In this talk, I will present a recent result where, for the first time, sufficient conditions have been obtained for nonlinear causality and local well-posedness of IS like theories. Also, necessary conditions are obtained, imposing some strong constraint over the transport coefficients of the theory. In particular, these necessary conditions have been used in recent works to show that several results obtained so far for the QGP are based on numerical simulations that violate causality.

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