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What happens in hydrodynamic simulations of heavy-ion collisions when causality is violated?

It was recently discovered that Israel-Stewart theory is not as causal as we thought [1]. When a fluid expands too fast, as in heavy ion simulations at early times, the large viscous stresses modify the propagation speeds, leading to superluminal signaling [2]. Since we would not trust hydrodynamic information speeds anyway, this may not sound like such disconcerting news, were it not for some recent theorems that link causality violations to instabilities due to time-reversed dissipation [3]. In this talk, I will discuss the physical implications of early-time causality violations in heavy-ion simulations, and how current state-of-the-art hydrodynamic solvers such as MUSIC deal with the expected early-time pathologies [4]. Particular attention will be devoted to the following pressing question: How can hydrodynamic simulations of heavy-ion collisions be seemingly stable when theory indicates they should not be?

[1] Bemfica, Disconzi, Hoang, Noronha, Radosz; Phys. Rev. Lett. 126 (2021) 22, 222301
[2] Plumberg, Almaalol, Dore, Noronha, Noronha-Hostler; Phys. Rev. C 105 (2022) L061901
[3] Gavassino; Phys. Rev. X 12 (2022) 4, 041001
[4] Gavassino, Soares-Rocha, Singh, Paquet; to appear.

Category

Theory

Collaboration (if applicable)

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