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Physics-informed neural networks for angular-momentum conservation in computational relativistic spin hydrodynamics

Theoretical developments in relativistic spin hydrodynamics, which explicitly describes the internal angular momentum of a fluid element as spin, have progressed rapidly since the experimental observation of the global spin polarization of Λ hyperons in relativistic heavy-ion collisions. However, numerical simulations of relativistic spin hydrodynamics remain underdeveloped due to significant computational challenges, one of which is the accurate preservation of angular-momentum conservation.

In this work, we demonstrate the application of physics-informed neural networks (PINNs), a neural-network-based learning framework, to simulations of relativistic spin hydrodynamics, as has been done for non-relativistic hydrodynamics. We highlight the flexibility of PINNs, which allows angular-momentum conservation to be imposed as a penalty in the training process. As a proof of concept, we consider a rotating fluid confined in a cylindrical container.

We first show that angular-momentum conservation can be accurately preserved by incorporating it into the loss function. We then numerically investigate the role of the rotational viscous effect in driving the conversion between orbital and spin angular momentum.

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