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Deep Learning for Studying Collective Flow and Chiral Magnetic Effect

Deep learning (DL) techniques have emerged as powerful tools for advancing our understanding of high-energy nuclear physics. We employ DL methods to probe two crucial phenomena: collective flow in small colliding systems and the chiral magnetic effect (CME) in heavy-ion collisions.

Collective flow is similar between small colliding systems ($p + p$ and $p + \mathrm{A}$ collisions) and large colliding systems (peripheral A+A collisions) at the CERN Large Hadron Collider (LHC) for events with similar multiplicity. To study the differences in collective flow generation mechanism between small and large colliding systems, we employ a point cloud network to identify $p + \mathrm{Pb}$ collisions and peripheral $\mathrm{Pb} + \mathrm{Pb}$ collisions at $\sqrt{s_{NN}} = 5.02$ TeV generated from a multiphase transport model (AMPT). After removing the discrepancies in the pseudorapidity distribution and the p_{T} spectra, we capture the discrepancy in collective flow, revealing an increased distinction with higher final hadron multiplicity and parton scattering cross sections.

On the other hand, the search for chiral magnetic effect (CME) in heavy-ion collisions has attracted long-term attention. Multiple observables are proposed, but all suffer large background contaminations, especially from collective flow, generating with quark gluon plasma (QGP) evolution. We design a U-Net architecture based on deep convolutional neural networks to reconstruct the CME signal by reversing the evolution of the CME signal inside the QGP. Trained on AMPT-generated datasets, our model effectively reconstructs the charge separation in phase space, providing a strong AI technique for future experimental search for the CME.

Reference:

[1] S.Guo, H.S.Wang, K.Zhou and G.L.Ma, Machine learning study to identify collective flow in small and large colliding systems, Phys.Rev.C 110 (2024), 2305.09937
[2] S.Guo, L.X. Wang, K.Zhou and G.L.Ma, in preparation.

Category

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