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Optimal Observables for the Chiral Magnetic Effect from Machine Learning

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The detection of the Chiral Magnetic Effect (CME) in relativistic heavy-ion collisions remains challenging due to substantial background contributions that obscure the expected signal. In this Letter, we present a novel machine learning approach for constructing optimized observables that significantly enhance CME detection capabilities. By parameterizing generic observables constructed from flow harmonics and optimizing them to maximize the signal-to-background ratio, we systematically develop CME-sensitive measures that outperform conventional methods. Using simulated data from the Anomalous Viscous Fluid Dynamics framework, our machine learning observables demonstrate up to 90\% higher sensitivity to CME signals compared to traditional γ and δ correlators, while maintaining minimal background contamination. The constructed observables provide physical insight into optimal CME detection strategies, and offer a promising path forward for experimental searches of CME at RHIC and the LHC.

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