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Through the minimal distances of nucleon pair to Unravel the v_2 and v_3 Puzzle in Ultra-Central Pb + Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV

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In the high-energy physics, particularly within the context of heavy-ion collisions conducted at the Large Hadron Collider (LHC), there exists a puzzle where viscous hydrodynamics fails to accurately depict the experimental data for the second and third flow harmonics, $v_2\{2\}$ and $v_3\{2\}$, in ultra-central Pb + Pb collisions at 2.76 TeV. This study proposes a novel approach to address this issue by reducing the initial state fluctuations through the augmentation of the minimum inter-nucleon distance within the nucleus. It was observed that increasing this minimum distance resulted in a reduction of the initial eccentricity, as compared to the predictions made by the Woods-Saxon model. Consequently, a lower ratio of shear viscosity to entropy density, η/s, is necessitated. Employing the TRENTo model, this research calculated the eccentricities within the 0–1% centrality class and subsequently determined the flow harmonic coefficients $v_2\{2\}$ and $v_3\{2\}$ using the (3+1) dimensional viscous hydrodynamics models CLVisc. By comparing various scenarios with different minimum distances between nucleons, this study discovered that a reduction in initial state fluctuations has a substantial impact on resolving the aforementioned puzzle within the nucleus of Pb. This conclusion not only addresses the specific issue of flow harmonic discrepancies but also contributes to a broader understanding of the initial state conditions in heavy-ion collisions. By refining our models to better reflect the true initial conditions, this study enhances the predictive capabilities of hydrodynamic simulations, thereby advancing the field of high-energy physics.

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