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# Understanding initial state fluctuations

In event-by-event hydrodynamics, the initial distribution of participants in the azimuthal plane fluctuates from event to event. We study the dipole asymmetry $\epsilon_1$, eccentricity $\epsilon_2$, and triangularity $\epsilon_3$, as a function of centrality, both analytically as well as numerically. These Fourier harmonics of the initial-state geometry have been shown to largely determine the flow coefficients $v_1$, $v_2$, and $v_3$, respectively, in hydrodynamic calculations, and so are of significant theoretical interest. We consider fluctuations in the centre-of-mass of the participant distribution to order 6. In an independent-source model, we derive expressions for $\epsilon_3\{2\}$, $\epsilon_3\{4\}$, $\epsilon_1\{2\}$, and various correlations among the orientation angles $\psi_1$, $\psi_3$ and $\psi_2 \equiv \Psi_{PP}$ which is the participant-plane angle. We compare these analytic results with numerical results based on Monte-Carlo Glauber and Monte-Carlo KLN models. We find that the independent-source model explains many of the features seen in the Monte-Carlo models, and thus can provide insight into the fluctuations seen in heavy-ion collisions.

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