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Quantifying the applicability of the fluid dynamical description of AA and pA collisions using Knudsen numbers

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We investigate the applicability of fluid dynamics in ultrarelativistic heavy ion (AA) collisions and high multiplicity proton nucleus (pA) collisions.
In order for fluid dynamics to be applicable the microscopic and macroscopic scales of the system have to be sufficiently separated. The degree of separation can be quantified by the ratio between these scales, usually refered as the Knudsen number. In this work, we calculate the Knudsen numbers reached in fluid dynamical simulations of AA and pA collisions at RHIC and LHC energies. For this purpose, we consider different choices of shear viscosity parameterizations, initial states and initialization times. We then estimate the values of shear viscosity for which the fluid dynamical description of ultrarelativsitic AA and pA collisions breaks down. In particular, we calculate how such values depend on the initial condition and system size. We found that the maximum shear viscosity allowed in AA collisions is of the order $\eta/s \sim 0.1 - 0.2$, which is similar in magnitude to the viscosities currently employed in simulations of heavy ion collisions. For pA collisions, we found that such limit is significantly lower, being less than $\eta/s = 0.08$.

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