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Extracting the bulk viscosity of the quark-gluon plasma

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Currently, most fluid-dynamical simulations of relativistic heavy ion collisions take into account only dissipative effects originating from shear viscosity. However, there is no a priori reason to neglect bulk viscosity since the actual order of magnitude and temperature dependence of this transport coefficient is unknown, and could be significant. In this work, we explore the phenomenological implications of a nonzero bulk viscosity coefficient on transverse momentum spectra and azimuthal momentum anisotropy. We then extract the optimal values of the bulk and shear viscosity coefficients that are able to describe these observables. For ultracentral heavy ion collisions, measured by ATLAS and CMS, we perform this analysis using several initial condition models. For other centrality classes, we determine these coefficients using the IP-Glasma initial condition model. Our fluid-dynamical description is the most complete available and includes all possible second order terms that appear in Israel-Stewart theory, including those that couple bulk viscous pressure to shear stress. The transport coefficients of all terms are computed using kinetic theory. We find that the optimum values of shear viscosity extracted from data can be modified up to 50% when bulk viscosity is included.

We further discuss the effects of baryon chemical potential on the shear viscosity of bulk nuclear matter. We show that a hadron resonance gas with large baryon number density is closer to the ideal fluid limit than the corresponding gas with zero baryon number.

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