Contribution ID: **414** Type: **Poster**

Insights into the interplay of momentum, multiplicity and the speed of sound in heavy-ion collisions

There have been recent proposals that the speed of sound of the quark-gluon plasma can be measured from multiplicity and mean transverse momentum (p_T) measurements in ultracentral heavy-ion collisions, based on thermodynamics arguments and numerical simulations [1]. The CMS Collaboration has used this approach to extract values of the speed of sound remarkably consistent with lattice QCD calculations [2]. We use a minimal model of ultracentral heavy-ion collisions based inviscid relativistic hydrodynamics to study the relation between the speed of sound and the hadronic multiplicity and average energy. We derive an analytical expression for the speed of sound in terms of the total particle multiplicity and average energy, which we relate to the original proposal. We discuss the role of rapidity and p_T cuts in breaking the relation between the true speed of sound and the one obtained from multiplicity and p_T measurements, finding corrections that depends on the system's lifetime and initial conditions [3].

[1] F. G. Gardim et al Nature Phys. 16, 615 (2020); F. G. Gardim, G. Giacalone, and J.-Y. Ollitrault, Phys. Lett. B 809, 135749 (2020)
[2] A. Hayrapetyan et al. (CMS) S. Rept. Prog. Phys. 87, 077801 (2024)
[3] G. S. Rocha, L. Gavassino, M. Singh \& J.-F.Paquet, Phys. Rev. C 110 (2024) 3, 034913

Category

Theory

Collaboration (if applicable)

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Session Classification: Poster session 2

Track Classification: Collective dynamics & small systems