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Medium response in asymmetric di-jet events from full 3-D hydro

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We develop a fully (3+1)-dimensional relativistic hydrodynamic model with source terms to analyze large angle emission of low-p_T particles in asymmetric di-jet events. In Pb-Pb collision experiments at LHC, a large number of low-p_T hadrons at large angles from a sub-leading jet is observed in asymmetric di-jet events by the CMS Collaboration [1]. The total transverse momentum of the leading-jet balances that of the sub-leading jet together with the low-p_T particles spread over wide angles from sub-leading jet axis.Motivated by the experimental fact, we analyze asymmetric di-jet events to understand the transport dynamics of the transverse momentum balance in the three-dimensionally expanding QGP.

The space-time evolution of the quark-gluon plasma (QGP) realized experimentally in heavy ion collisions at collider energies is well described by relativistic
hydrodynamics. High energy partons are also produced through initial hard scatterings and have to traverse the QGP fluid. The energy and momentum of these traversing partons are lost in the medium through strong interaction between them. Thus jet quenching phenomena provide an important clue to extract one of the substantial properties of the QGP, namely stopping power against energetic partons. The question then arises, "Where and how do these lost energies and momenta diffuse inside the medium?" Suppose deposited energy and momentum are quickly equilibrated, the traversing jet particles induce the collective flow in the QGP fluid. On the other hand, the background QGP fluid is by no means static, but expands itself at relativistic velocity. As a consequence, the collective flow results from the interplay of expansion of background QGP fluid and wake induced by jets.

This is the first attempt to numerically solve relativistic hydrodynamic equations with source terms without linearization in fully (3 + 1)-dimensional Milne coordinates. In the hydrodynamical equations, the source terms are introduced to account for the energy-momentum deposition from the energetic partons. It is shown that Mach cone-like structures are formed in the medium and distorted strongly by radial flow of the expanding background QGP fluid. As a result, we find that the low-p_T enhancement at large angles from the quenched jet compensates exactly the di-jet p_T-imbalance, similar to that observed by the CMS. Therefore these low-p_T particles spread over wide angle are originated from deposited energy and momentum transported by the collective expansion of the QGP.

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