Strong enhancement of jet-medium coupling in the quark-gluon plasma near transition temperature†

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A new, deconfined form of QCD matter known as the quark-gluon plasma is created in relativistic heavy ion collisions. In such collisions, highly energetic jets provide unique probe of the quark-gluon plasma properties. The observable quantifying jet energy loss is the nuclear modification factor, R_{AA} as well as its azimuthal anisotropy characterized by its second harmonic coefficient v_2. Both RHIC and LHC measurements have shown a sizable v_2 in the high p_t region.

Recently the temperature dependence of jet-medium coupling, which may be quantified by the so-called jet transport coefficient $\hat{q}(T)$, has attracted significant interest. As was first found in[1], the geometric anisotropy v_2 at high p_t is particularly sensitive to such temperature dependence, and a simultaneous description of high p_T R_{AA} and v_2 at RHIC requires a strong enhancement of jet-medium coupling in the near-T_c region. Furthermore, the near-T_c enhancement predicts a visible reduction of average opaqueness of the fireball from RHIC to LHC which was confirmed by analyzing how the R_{AA} evolves with beam energy[2,3]. Therefore phenomenologically there are robust evidences for such near-T_c enhancement, while a precise theoretical determination of such nontrivial T-dependence has not been known owing to the highly nonperturbative dynamics in the near-T_c regime.

One important approach for strongly coupled quark-gluon plasma is to use holographic QCD models. It is particularly important to introduce non-conformal physics that is most prominent around T_c. By constructing such a model[4], we have found that: 1) there are strong non-conformal, non-perturbative dynamics going on in the near-T_c region; 2) such dynamics leads to non-monotonic behavior in QGP thermodynamics as shown by the strong near-T_c peak of trace anomaly (which is well modeled by holography); 3) the same dynamics leads to non-monotonic behavior in QGP transport properties and in particular strong near-T_c enhancement of jet-medium coupling $\hat{q}/T^3$ (see Fig.1).

More recently we have developed a new jet quenching framework, CUJET3.0[5], that is shown to account well for both high p_T single inclusive hadron suppression R_{AA} and its azimuthal anisotropy v_2 at both RHIC and the LHC energies. CUJET3.0 model includes two new nonperturbative effects in the QCD transition temperature range $T \sim 140 - 250$ MeV: (1) the Polyakov loop suppression of color-electric scattering and (2) the enhancement of scattering due to emergent magnetic monopoles near T_c. We find that the CUJET3.0 jet transport parameter $\hat{q}(E,T)/T^3$ peaks near T_c and has very strong nonconformal E and T dependence up to $T \sim 400$ MeV. Extrapolating down to $E = 2$ GeV, we find a striking new connection between bulk perfect fluidity with $\eta/s \sim 0.1$ near T_c and high p_T high T perturbative jet quenching.

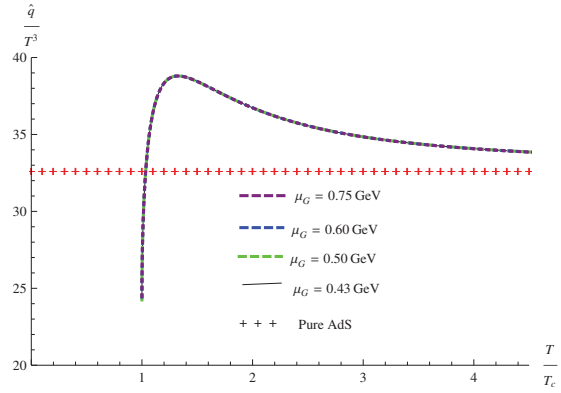

Fig. 1. Temperature dependence of jet-medium coupling from a non-conformal holographic QCD model[4].

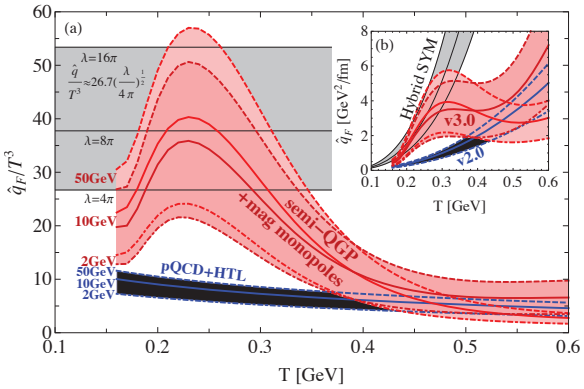

Fig. 2. Temperature dependence of jet-medium coupling from the CUJET3.0 model[5].

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