Energy dependence of jet transport parameter and parton saturation in quark-gluon plasma

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We study the evolution and saturation of the gluon distribution function in the quark-gluon plasma as probed by a propagating parton and its effect on the computation of jet quenching or transport parameter $\hat{q}$. For thermal partons, the saturation scale Q_s^2 is found to be proportional to the Debye screening mass μ_D^2. For hard probes, evolution at small $x = Q_s^2/6ET$ leads to jet energy dependence of $\hat{q}$. We study this dependence for both a conformal gauge theory in weak and strong coupling limit and for (pure gluon) QCD. The energy dependence can be used to extract the shear viscosity η of the medium since η can be related to the transport parameter for thermal partons in a transport description. We also derive upper bounds on the transport parameter for both energetic and thermal partons. The later leads to a lower bound on shear viscosity-to-entropy density ratio which is consistent with the conjectured lower bound $\eta/s \geq 1/4\pi$. Implications on the study of jet quenching at RHIC and LHC and the bulk properties of the dense matter are discussed.