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Anomalous diffusion in QCD matter

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Transverse momentum broadening (TMB) of energetic partons in QCD matter plays a central role in a variety of processes studied at colliders to probe QCD ranging from jet suppression in heavy ion collisions (HIC) to TMD gluon distributions that encode information on the 3D structure of the proton and nuclei in electron-proton or proton-proton collisions. We investigate in this work [1] the leading quantum corrections to the TMB distribution of fast partons in large QCD media. We show in particular that the resummation to all orders of double logarithmic contributions from gluon radiation in the presence of a saturation boundary yields a universal distribution which exhibits anomalous scaling of super diffusive type in contrast with normal diffusion seen at tree level. Exploiting a formal analogy with traveling waves in reaction-diffusion processes and gluon saturation we derive exact pre-asymptotic analytic solutions for fixed [1] and running coupling [2].

This remarkable anomalous diffusion caused by nonlocal quantum corrections is reflected by the emergence of a heavy tail at large transverse momentum, akin to Lévy random walks, which may have measurable effects in dijet production in HIC.

Refs:

- [1] Paul Caucal and Yacine Mehtar-Tani (BNL), 2109.12041 [hep-ph]
- [2] Paul Caucal and Yacine Mehtar-Tani (BNL), in preparation

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