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Electromagnetic radiation from jet-medium interactions in the Quark-Gluon Plasma

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Ultra-relativistic heavy-ions collisions performed at the Relativistic Heavy-Ion Collider (RHIC) and the Large Hadron Collider (LHC) produce a deconfined state of quarks and gluons, called the quark-gluon plasma (QGP). One of the primary goals of these collisions is to infer the properties of the QGP through the modifications it imparts on the evolution of high-energy quarks and gluons (also known as hard partons) in the QGP. At early times following a heavy-ion collision, partons are produced in a highly excited (i.e. highly virtual) state and undergo energy loss via bremsstrahlung radiation. At later times, multiple scatterings in the QGP become the dominant mechanism of parton energy loss. To better understand the dynamics of the parton energy loss, we focus on the production of photons from the highly virtual hard quarks traversing the QGP. In prior efforts, scattering rates have been computed for the case of gluon bremsstrahlung off from a highly virtual quark traversing the QGP. To minimize hadronization uncertainties, the present study focuses on photon emission rates. Photons avoid hadronization effects and provide an independent probe to constrain the parton energy loss transport coefficients.

We used the generalized factorization procedure, employed in the e-A deep-inelastic scattering, to derive an improved single emission and single scattering collision kernel for photon production, going beyond traditional in-medium gluon exchange approximation. We identified two types of scattering kernels at $O(\alpha_{em}\alpha_s)$ giving the following final states: (i) real photon and real quark, (ii) real photon and real gluon. We will present these scattering kernels [1] and argue that a better way to extract properties of the QGP is to simultaneously use photons and jets.

Reference:

(1) A. Kumar and G. Vujanovic, arXiv:2502.02667 (2025)

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