In-medium fluctuations in the GLV formalism

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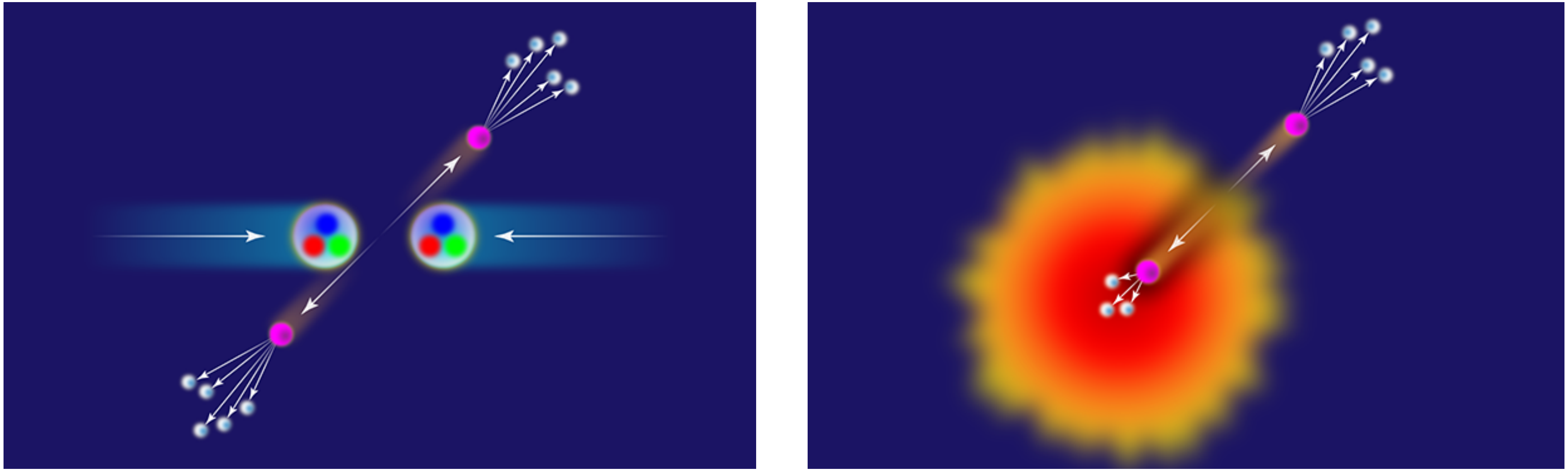
Jets

p+p A+A



APS/Alan Stonebraker

- Jets are cone-shaped sprays of hadrons evolved from high-energy partons;
- Jets are main available probes of the matter in HIC and at EIC;
- Jets see nuclear matter at multiple scales, “X-ray” the medium;

The GLV calculation

- The jet-medium interaction (the energy loss) can be treated perturbatively in a QCD based model leading to a successful description of many experimental observations;

- The simplest version of this description is based on a model potential for in-medium sources integrated into a perturbative calculation for QCD amplitudes in the eikonal approximation (large jet energy)

$$H_{int} = \sum_i \int d^3x\, v(x - x_i)(T_a)_i \phi^\dagger(x,t) T_a(R)(i\overleftrightarrow{\partial_t})\phi(x,t)$$

written here for scalar quarks, where the sum goes over the sources;

- It is assumed that the sources cannot interact with each other and the averaging over sources in the amplitude squared, in fact, reduces to a single sum (no source interference);

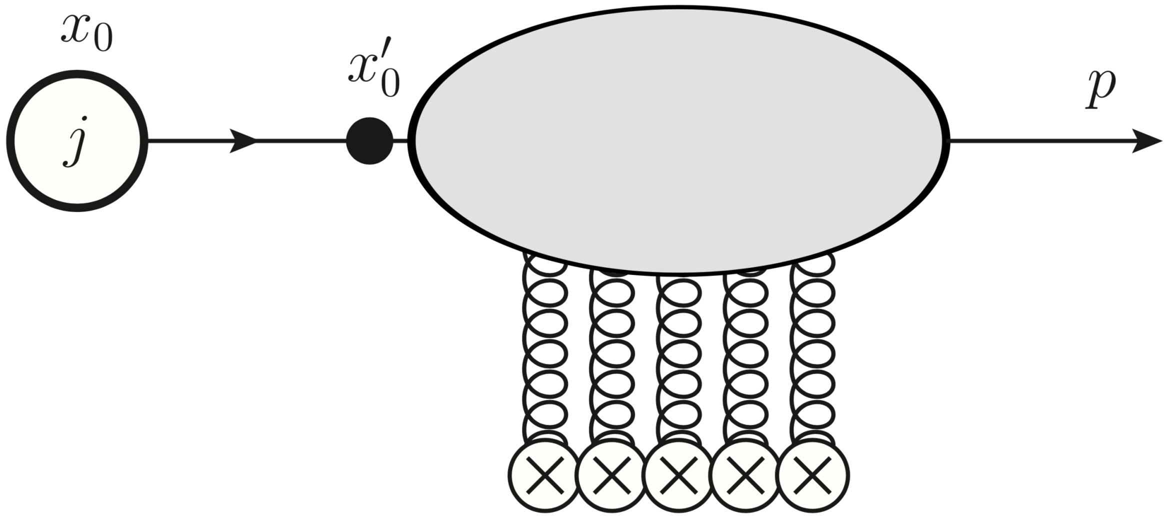
The GLV calculation

Elastic scattering

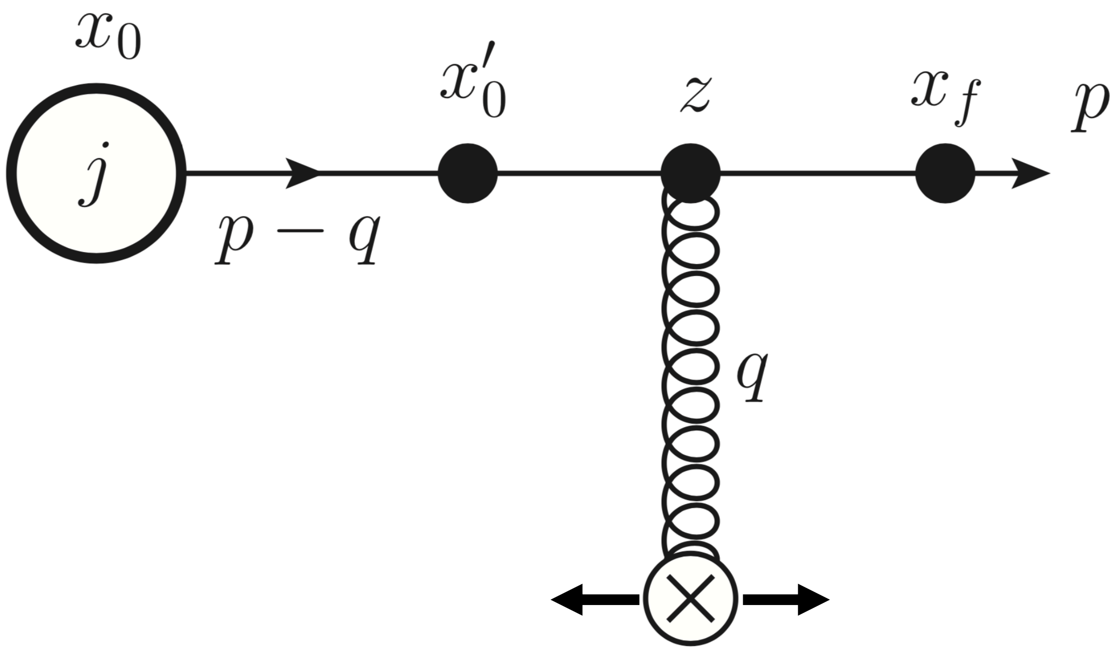
As an illustration let's consider the momentum broadening in the medium:

$$d^3N = \frac{1}{d_T}\mathrm{Tr}\,|M_0 + M_1 + M_2 + \cdots|^2 \frac{d^3\vec{\mathbf{p}}}{2|\vec{\mathbf{p}}|(2\pi)^3}$$

$$= d^3N_0 + d^3N_1 + \frac{1}{d_T}\mathrm{Tr}\,\left[2\,\mathrm{Re}(M_1 M_0^*) + 2\,\mathrm{Re}(M_2 M_0^*)\right] \frac{d^3\vec{\mathbf{p}}}{2|\vec{\mathbf{p}}|(2\pi)^3}$$



Medium Motion Effects in GLV



$$H_{int} = \cancel{\sum_i \int d^3x\, v(x - x_i)(T_a)_i \phi^\dagger(x,t) T_a(R)(i\overleftrightarrow{\partial_t})\phi(x,t)}$$

$$A^\mu = 2\pi \sum_i e^{iq\cdot x_i} \frac{i\bar{g}_{eff}(T_a)_i}{q^2 + \mu^2}(2p_{S,i} - q)^\mu \delta\left((p_{S,i} - q)^2 - M^2\right)$$

Medium Motion Effects in GLV

$$\left\langle |M_1|^2 \right\rangle = \frac{C_F}{2N_c} \int dz \, \frac{d^2 q}{(2\pi)^2} \, \rho \, |v(q_T^2)|^2 \, |j(E, \boldsymbol{p}_\perp - \boldsymbol{q}_\perp)|^2 \Big[1 + \boldsymbol{u}_\perp \cdot \boldsymbol{\Gamma}(\boldsymbol{q}_\perp) \Big]$$

$$\begin{aligned} \boldsymbol{\Gamma}(\boldsymbol{q}_\perp) = & -2 \frac{\boldsymbol{p}_\perp - \boldsymbol{q}_\perp}{(1 - u_{i\,z})E} + \frac{\boldsymbol{q}_\perp}{(1 - u_{i\,z})E} \left(\frac{(p-q)_T^2 - p_T^2}{\sigma(q_T^2)} \right) \frac{d\sigma}{dq_T^2} \\ & - \frac{\boldsymbol{q}_\perp}{1 - u_z} \left(\frac{1}{N_0(E, \boldsymbol{p}_\perp - \boldsymbol{q}_\perp)} \frac{\partial N_0}{\partial E} \right) . \end{aligned}$$

Summary

- We considered **the leading sub-ekonal corrections** to the jet-broadening and soft gluon emission in the GLV setup due to the medium evolution;
- The medium velocity results in **a non-zero energy transfer** and its effects can be systematically taken into account;
- If the velocity is varying in space and time **it affects the source averaging procedure**. In the simplest approximations one can study the corresponding corrections to the amplitudes analytically;
- Our new formalism can be also used to take into account other forms of in-medium fluctuations. For instance it allows to study TMDs through the jet energy loss at EIC since the source motion is coupled to the jet energy loss;