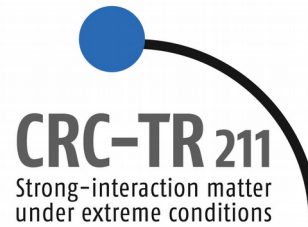# Nonperturbative phenomena

in jet modification

Niels Schlusser

in collaboration with: Guy D. Moore, Sören Schlichting,

Ismail Soudi, Philipp Schicho, Jacopo Ghiglieri

Moore, NS: *Phys. Rev. D100* (2019)
Moore, NS: *Phys. Rev. D101* (2019)
Moore, NS: *Phys. Rev. D102* (2020)
Moore, Schlichting, NS, Soudi: *2105.01679*
Ghiglieri, Moore, Schicho, NS: *in preparation*

TECHNISCHE UNIVERSITÄT DARMSTADT

CRC–TR 211
Strong-interaction matter
under extreme conditions

UNIVERSITY OF HELSINKI

What can we learn about jets

from lattice EQCD?

Niels Schlusser

in collaboration with: Guy D. Moore, Sören Schlichting,

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Light cone formalism

- Jet splitting rates:

$$\frac{\mathrm{d}P_{bc}^a}{\mathrm{d}k} \sim \int \mathrm{d}t' \, \nabla_{\boldsymbol{x}_\perp} \nabla_{\boldsymbol{y}_\perp} \mathcal{K}(t', \boldsymbol{x}_\perp; t, \boldsymbol{y}_\perp; p, k)\Big|_{\boldsymbol{x}_\perp = \boldsymbol{y}_\perp = 0}$$
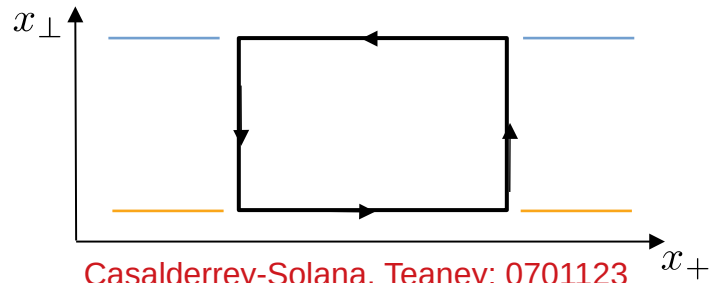
- Transversal Schrödinger equation:

$$\left(i\partial_t + \frac{p\nabla_{\boldsymbol{x}_\perp}^2}{2k(p-k)} + \frac{m_a^2}{2p} - \frac{m_b^2}{2k} - \frac{m_c^2}{2(p-k)} + i\mathcal{C}_3 \right) \mathcal{K}$$
$$= i\delta(t - t')\delta(\boldsymbol{x}_\perp - \boldsymbol{y}_\perp)$$

Important quantities

- Collision kernel

$$C(q_\perp) = \frac{\mathrm{d}\Gamma}{\mathrm{d}^2 q_\perp \, \mathrm{d}L}$$

- Asymptotic mass

$$m_\infty^2 = C_\mathrm{R} \left(Z_\mathrm{g} + Z_\mathrm{f} \right)$$

- Wilson loop

Casalderrey-Solana, Teaney: 0701123

- Force-force-correlator

Braaten, Pisarski (1992)
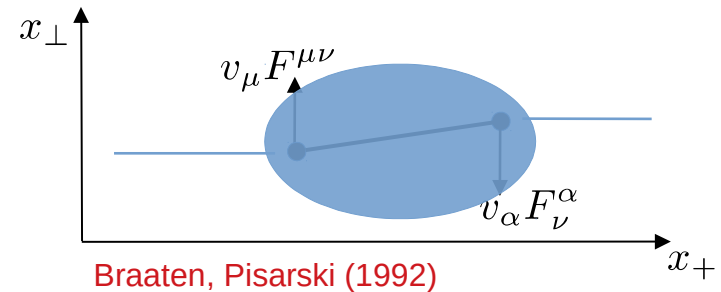
Nonperturbative gluon-zero-mode contributions:

→ calculate in lattice EQCD

Caron-Huot: 0811.1603

Rigorous connection to full QCD

- Strategy:

$$C_{\mathrm{QCD}}(x) = \underbrace{\left(C_{\mathrm{QCD}}(x) - C_{\mathrm{EQCD}}(x)\right)}_{\text{UV dominated}} + \underbrace{C_{\mathrm{EQCD}}(x)}_{\text{lattice}}$$

- Done for $C(b_\perp)$ ✓
  Arnold, Xiao: 0810.1026; Ghiglieri, Kim: 1809.01349; Moore, Schlichting, NS, Soudi: 2105.01679

- Still to be done for m_∞^2
  Ghiglieri, Moore, Schicho, NS: in preparation
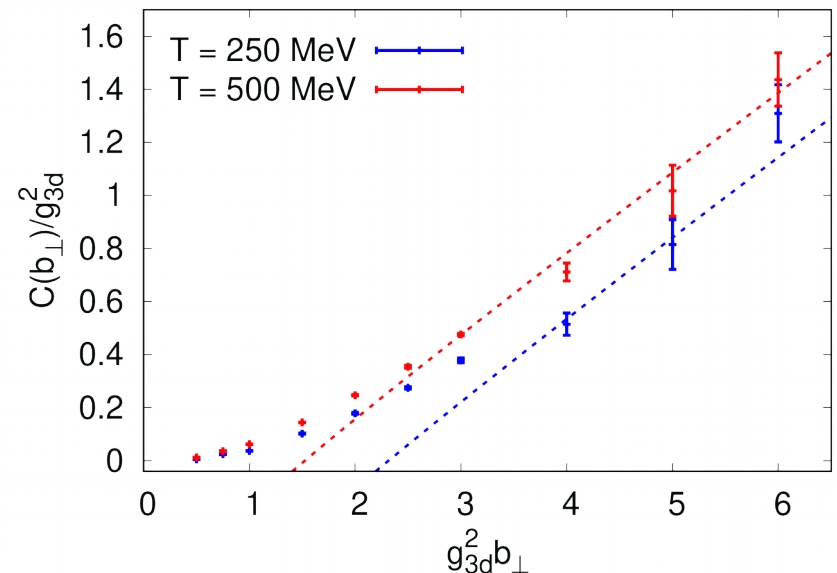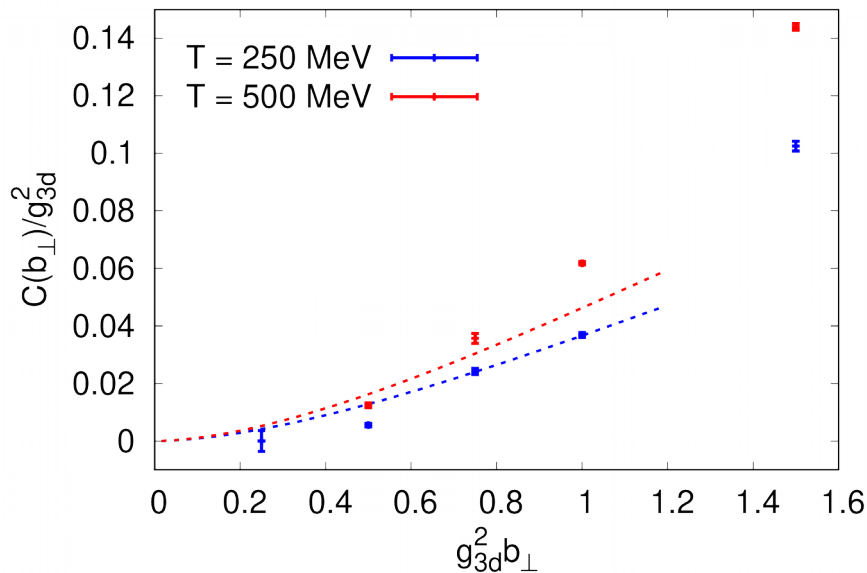
Nonperturbative collision kernel

Moore, NS: 1911.13127
Moore, Schlichting, NS, Soudi: 2105.01679

- Small $b_\perp$: perturbative limit

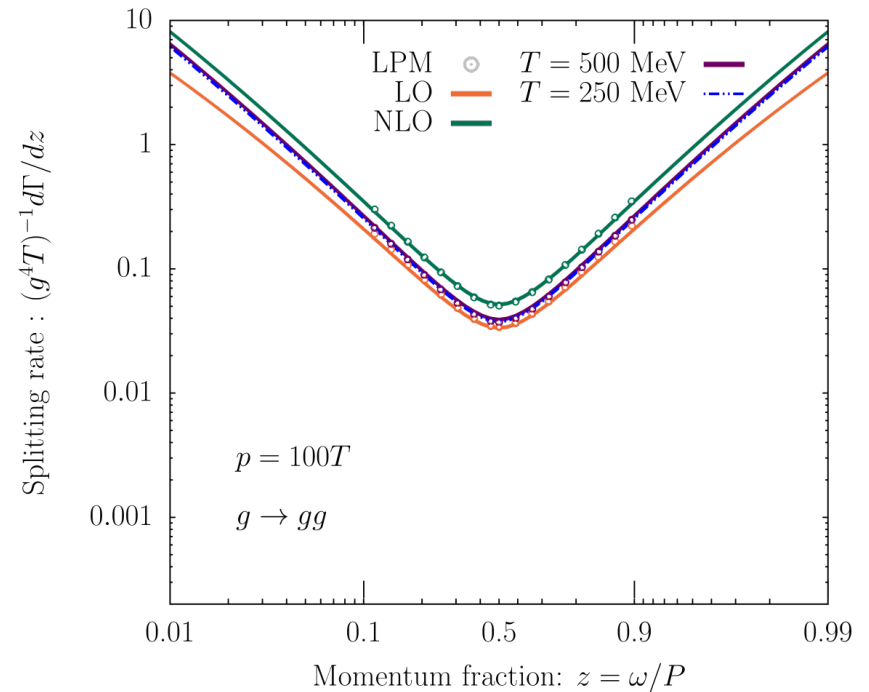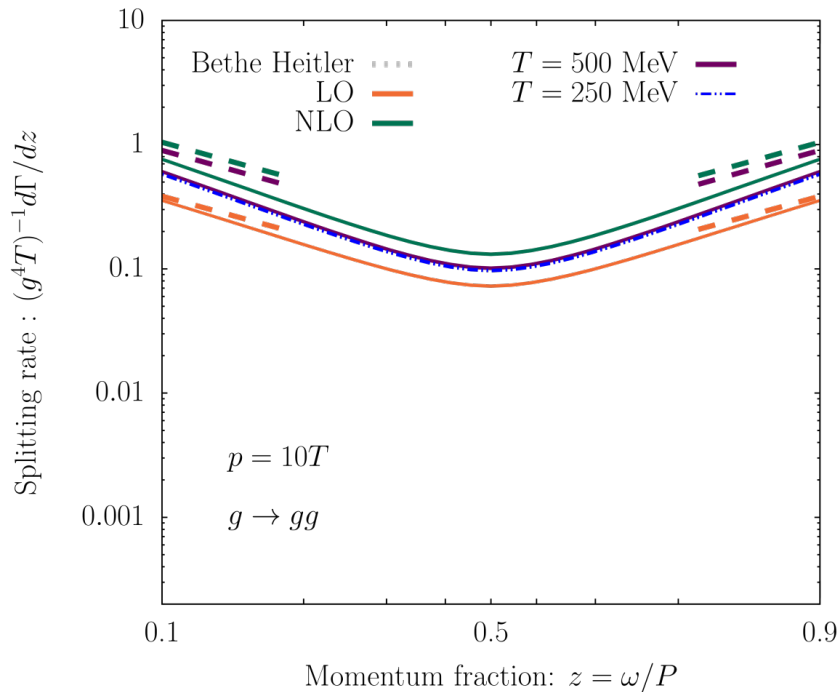$$C(b_\perp) \approx \left.\frac{\hat{q}}{4}\right|_\mu \cdot b_\perp^2$$

- Large $b_\perp$: Area-law-limit

$$C(b_\perp) \approx A + \sigma_{\mathrm{EQCD}}\, b_\perp$$

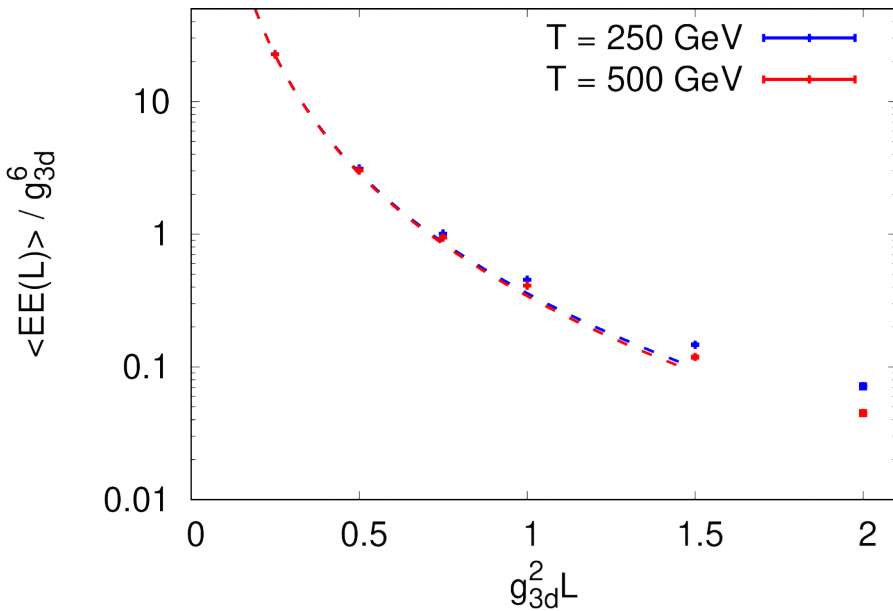# Nonperturbative splitting rates

Moore, Schlichting, NS, Soudi: 2105.01679

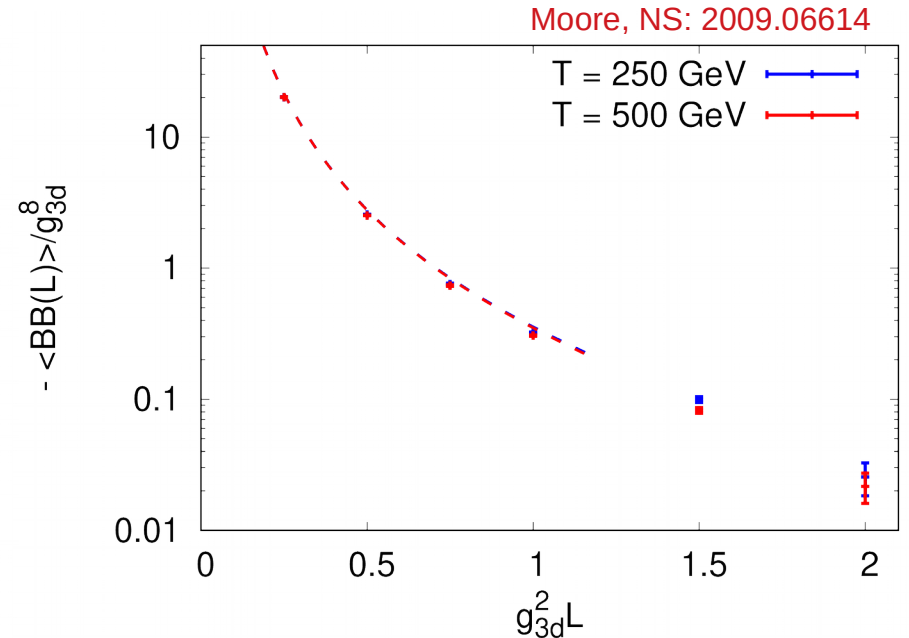- Extend to finite medium

- Incorporate nonperturbative m_∞^2

Asymptotic masses

- $\langle E(L)E(0)\rangle$-correlator:
- $\langle B(L)B(0)\rangle$-correlator:

- Take into account subleading $\langle E(L)B(0)\rangle$
- Do matching calculation

Summary and outlook

- Understanding jet modification (+other transport) involves soft QCD $\rightarrow$ (lattice) EQCD

- Key ingredients $C(b_\perp)$ and m^2_∞ from lattice EQCD

- Calculation of nonperturbative splitting rates possible

- Rigorous connection to full QCD needs more work

- Prepares the ground for NNLO-transport

- Plug results in event generator

Thank you!