#### Simulating heavy quarks and jets in the Glasma

by  $\mathcal{DA}$ vramescu

University of Jyväskylä Center of Excellence in Quark Matter

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Initial Stages, June 2023

#### Instead of motivation



#### Question: Do the hard probes (HPs) remember the Glasma (IS)?

#### Poster visitor: No, they don't!

This talk: Reasons not to neglect the IS for HPs transport

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## Overview



Glasma fields hard probes

Many studies (recall C. Andres' talk)  $\Rightarrow$  significant impact

This study: Classical colored transport for particles in fields

What fields?

SU(3) real-time lattice Yang-Mills equations What particles?

SU(3) classical charges Wong's equations

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SU(3) real-time lattice Yang-Mills equations

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# Approach



Prerequisite: Classical lattice gauge theory  $\xrightarrow{\text{solver}}$  Glasma fields

*Fresh work:* Glasma fields  $\stackrel{\text{background}}{\longleftrightarrow}$  ensemble of particles  $\stackrel{\text{solver}}{\longleftrightarrow}$  colored particle-in-cell



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### Glasma fields





Relevant scale  $Q_s$ Fields dilute after  $\delta \tau \simeq Q_s^{-1}$ , arrange themselves in correlation domains of  $\delta x_T \simeq Q_s^{-1}$ 

Boost-invariant, highly anisotropic



## Particles in YM fields (technicalities)



 $\begin{array}{l} \text{Wong's equations} \leftrightarrow \text{classical equations of motion for particles } (x^\mu, p^\mu, Q) \\ \quad \text{evolving in Yang-Mills fields } A^\mu \end{array}$ 



CPIC solver  $\xrightarrow{\text{assures}} Q \in \mathfrak{su}(3)$ , conservation of Casimir invariants

## Transport in Glasma



Coordinate trajectories

Momentum trajectories







 $\begin{array}{l} \mbox{Momentum broadening} \\ \langle \delta p_i^2(\tau) \rangle \equiv \langle p_i^2(\tau) \rangle - \langle p_i^2(\tau_{\rm form}) \rangle \end{array}$ 

Anisotropy  $\equiv \langle \delta p_L^2 
angle / \langle \delta p_T^2 
angle$ 

Infinitely massive quarks  $\langle \delta p_i^2(\tau) \rangle \big|_{m \to \infty} \propto \int_{\tau', \tau''} \langle E_i(\tau') E_i(\tau'') \rangle_{\text{lattice}}$ 

Dynamical quarks  $\leftrightarrow$  finite  $m, \tau_{\rm form}$  and  $p_T$   $\neq$ Static quarks  $\leftrightarrow m \rightarrow \infty$ 





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#### Two particle correlations

(Work in progress)

## Sketch of quark pair evolution







# Quantifying the decorrelation



Two particle correlations 
$$\mathcal{C}(\Delta\eta,\Delta\phi) = \frac{1}{N_{\rm pairs}} \frac{{\rm d}^2 N}{{\rm d}\Delta\eta {\rm d}\Delta\phi}$$

Initial 
$$\mathcal{C}(\tau_{\text{form}}) \propto \delta(\Delta \phi - \pi) \delta(\Delta \eta) \xrightarrow[\Delta \tau]{\text{Glasma}} \mathcal{C}(\tau_{\text{form}} + \Delta \tau) \xrightarrow[\text{extract}]{\text{extract}} \sigma_{\Delta \phi}(\Delta \tau), \sigma_{\Delta \eta}(\Delta \tau)$$



#### Dramatic effect for...



 $\ldots$  slow heavy quarks  $\Rightarrow$  correlation immediately washed out



## Dramatic effect for...

![](_page_21_Picture_1.jpeg)

... slow heavy quarks  $\Rightarrow$  correlation immediately washed out

![](_page_21_Figure_3.jpeg)

# Thank you!