Hydrodynamic approach to heavy-quark diffusion in the quark-gluon plasma

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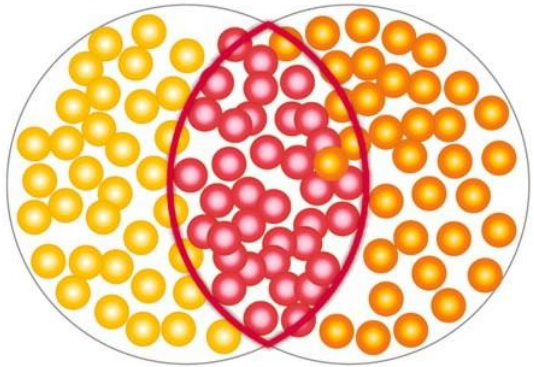
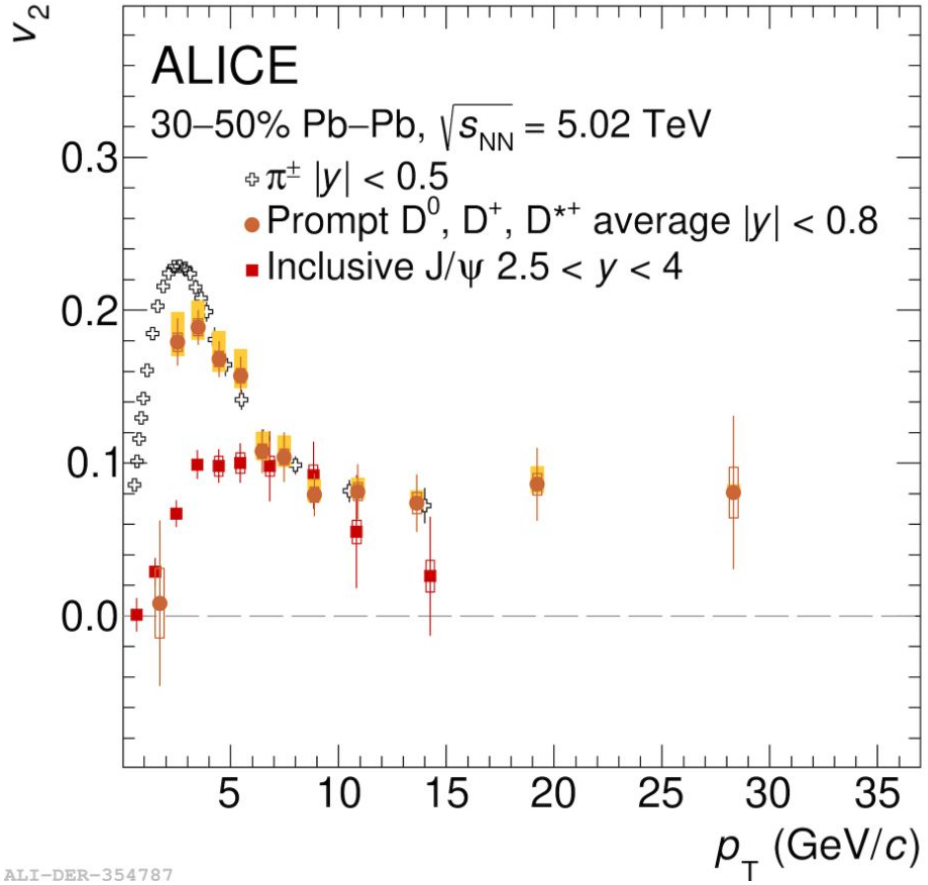
Motivation

J/Ψ and D mesons show elliptic flow

⇒ Sign of **thermalization**!



$$E\frac{d^3N}{d^3p} = E\frac{d^2N}{2\pi p_T dp_T dy}\left(1+\sum_{n=1}^{\infty} 2v_n \cos[n(\phi-\psi_{\mathrm{RP}})]\right)$$



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Heavy-quark diffusion current

$$N^\mu = n_0 u^\mu + \nu^\mu$$

$$\partial_\mu N^\mu = 0$$

conservation of $Q\bar{Q}$ pairs in the QGP

Equation of motion for the diffusion current needed!

Starting point: Fokker-Planck equation

$$k_0 \partial_t f_k + k^i \partial_i f_k = k_0 \frac{\partial}{\partial k^i}\left(A k^i f_k\right) - D g^{ij} \frac{\partial^2}{\partial k^i k^j} f_k$$

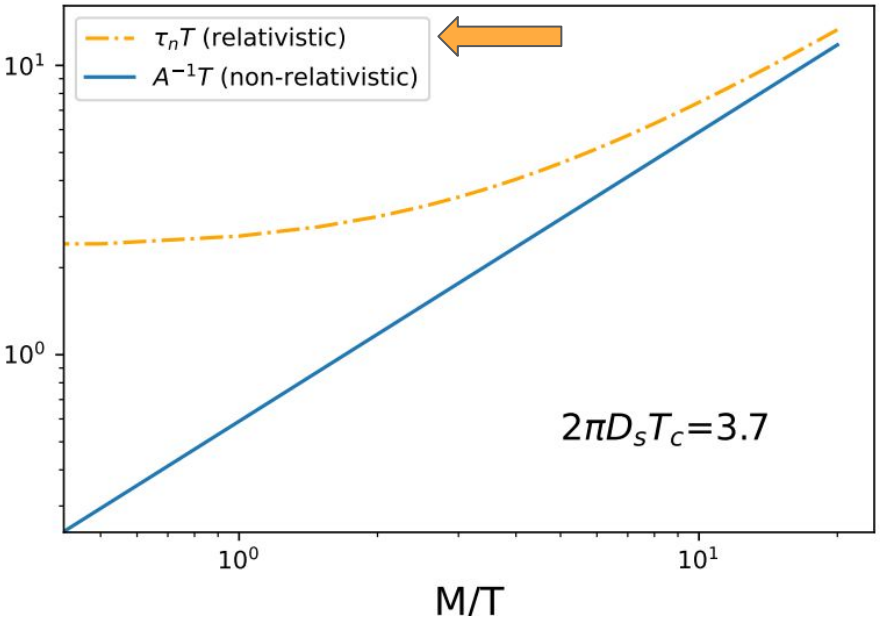
$$\tau_n \dot{\nu}^\mu + \nu^\mu = \kappa_n \nabla^\mu \left(\frac{\mu_{Q\bar{Q}}}{T}\right)$$

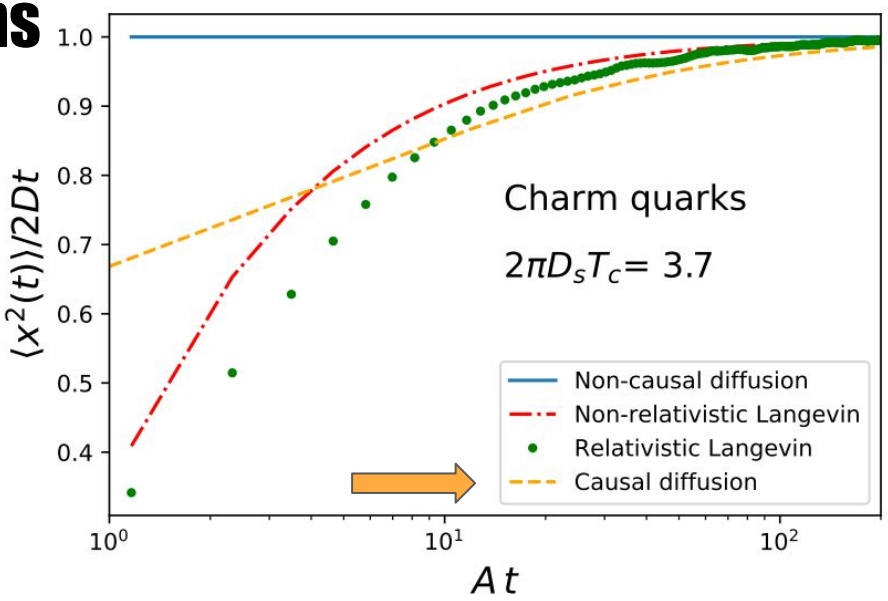
$$\tau_n = \frac{T}{D P_0} \int dK f_k E k^2$$

$$\kappa_n = D_s n_0 = \frac{T^2}{D} n_0$$

the model we deserve.. … maybe also the one we need!

Agreement with other calculations

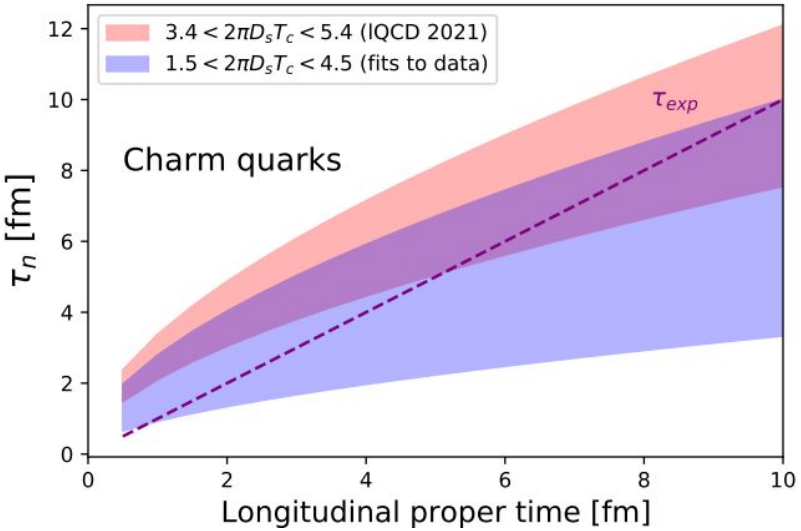


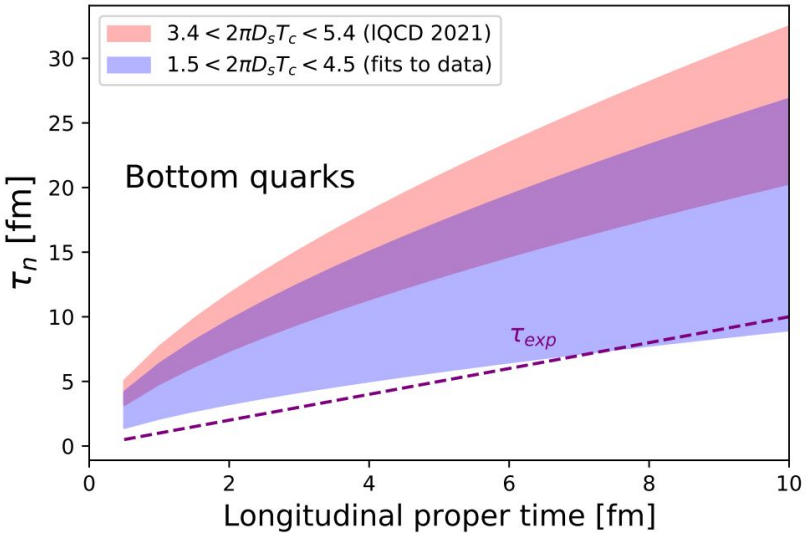


In the non-relativistic limit, **our model** agrees with transport models (Langevin/Fokker-Planck equation)!

Relaxation to hydrodynamics

Ds estimates in plots: lQCD [PRD 92 116003], fits to data [JHEP 01 (2022) 174]



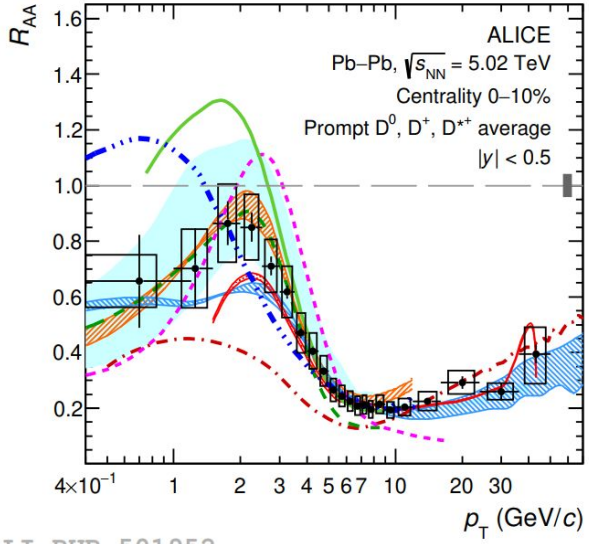


Compared with a Bjorken-like expansion, our model predicts that charm quarks relax to a **hydrodynamic** behaviour

Thermalization is possible for charm quarks!
… Less likely for bottom

Outlook

- Simulate the heavy-quark diffusion in realistic hydrodynamic simulation of the QGP
- Study interaction with other conserved currents



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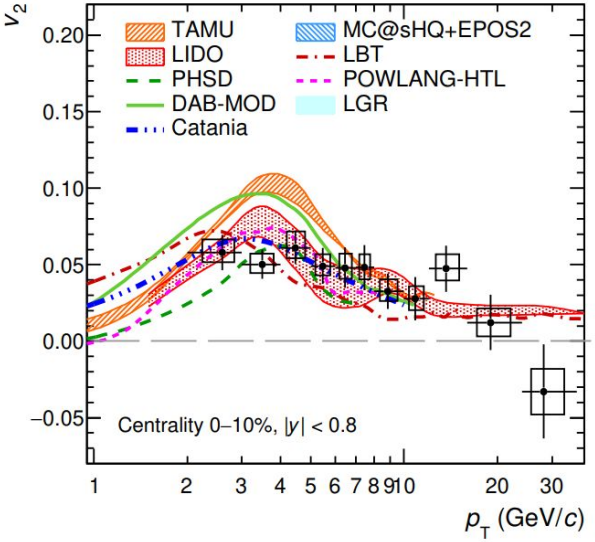

- Develop proper initial conditions for the HQ spatial distribution
- implement hadronization from the medium

We're just one hydro simulation away to add a new curve for **thermalized charm** to the zoo!