Heavy Quark Diffusion in AdS/CFT

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- AdS/CFT is a correspondence that relates certain Quantum Field Theories and certain String Theories.

Some characteristics of the correspondence.

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- We can think of AdS/CFT as a tool to compute interesting quantities in field theory.

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- All fundamental matter fields are in adjoint representation: A_μ, four Majorana fermions λ_i, six real scalars X_I.
- Many phenomenological models (AdS/QCD) improve on the previous points.

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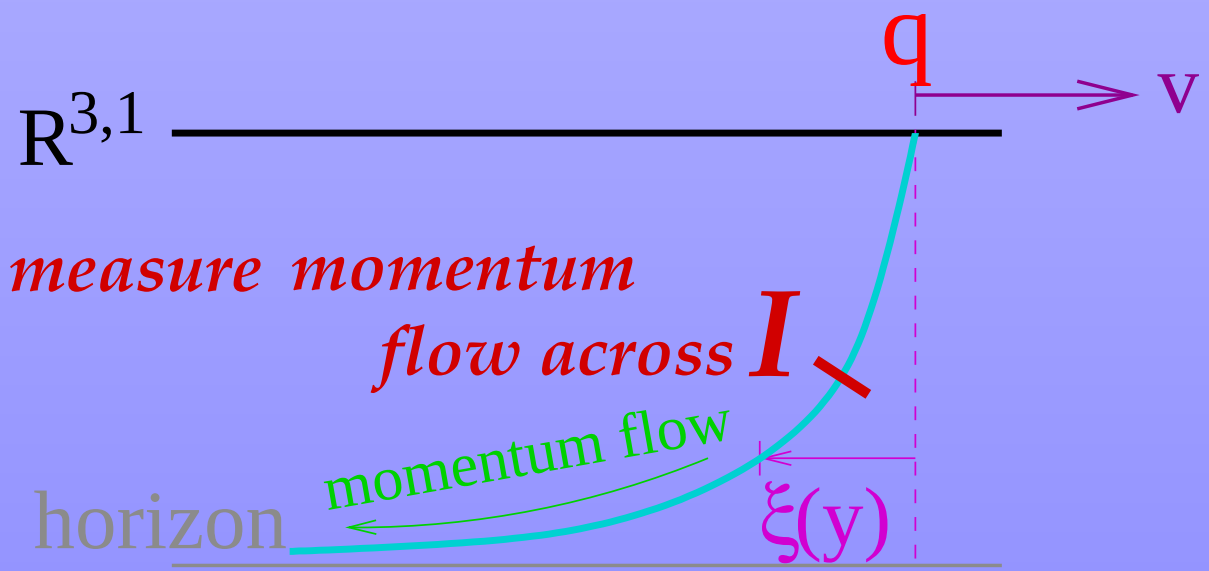
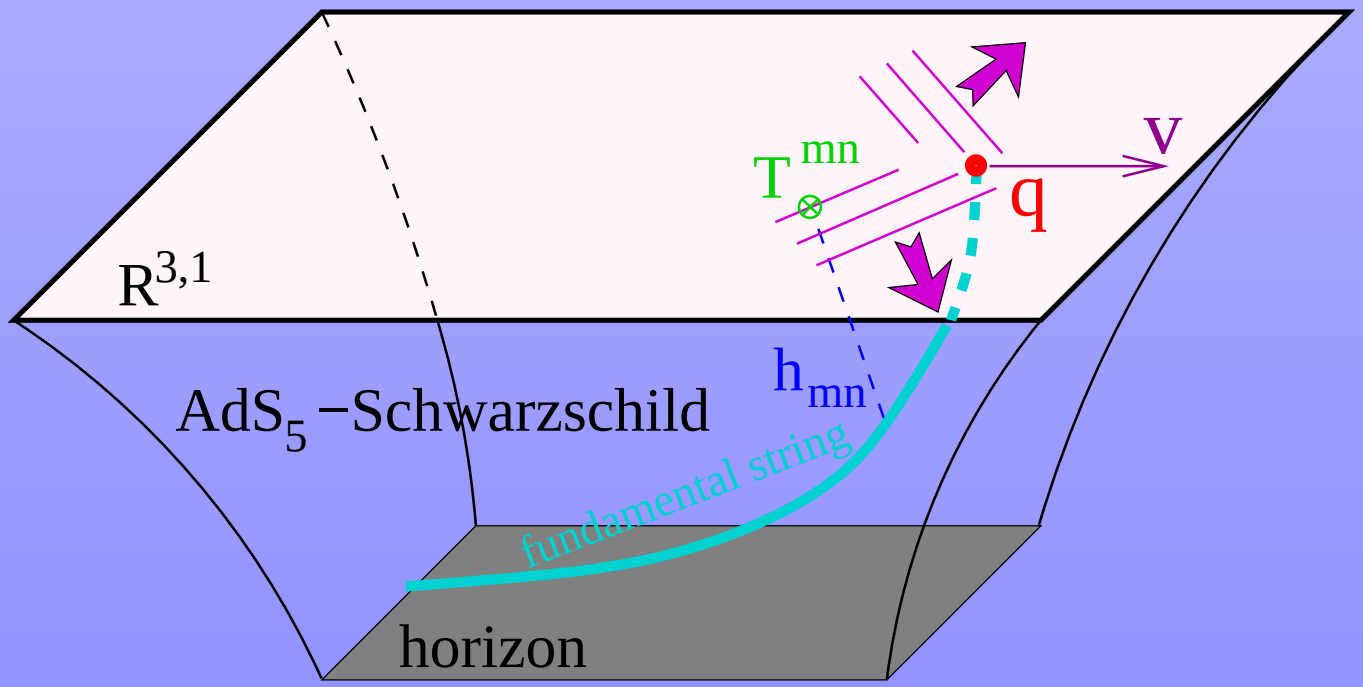
- We impose boundary conditions on the boundary of AdS for the string.
- The quark moves at a constant speed with energy provided by an external force.



The drag force is computed by measuring the momentum flux down the string. The position of $\mathcal{I}$ is arbitrary because the energy-momentum current is conserved.



In blue: the trailing string of an external quark, following. The dashed line shows classical propagation of a graviton from the string to the boundary, where its behavior can be translated into the stress-energy tensor $\langle T_{mn} \rangle$ of the boundary gauge theory.

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- $\tau = \frac{2M_q}{\pi\sqrt{\lambda}T^2}$.
- $\tau_{charm} \sim 2fm$, $\tau_{bottom} \sim 6fm$, for $T = 250MeV$.

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- For $\lambda = 5.5$ and $T = 250MeV$, $\hat{q} = 2GeV^{2}/fm$.

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- A running constant is introduced via the dilaton in five dimensions.
- Similar approach to the “hard wall“ and ”soft wall” models.
- The model consists of gravity plus a scalar in five dimensions.

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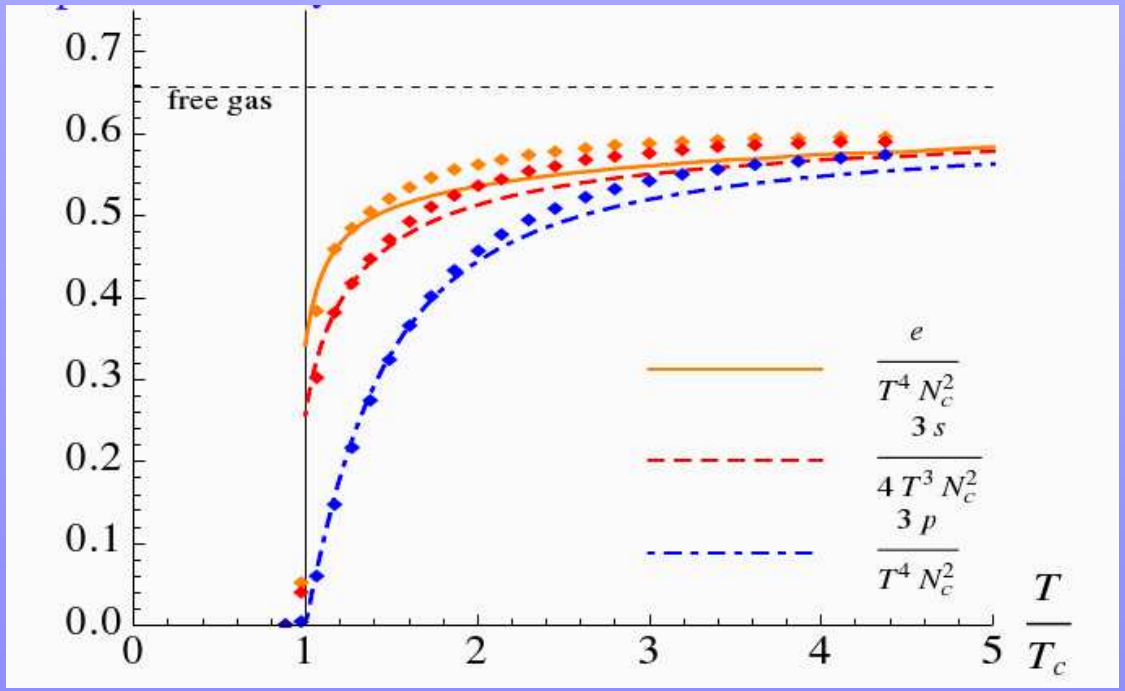
- Matching thermodynamics with lattice for high temperatures.
- These conditions give a first order transition - Hawking Page between the confined and the deconfined phase at $T_C \sim 250 MeV$.

Some thermodynamical quantities for the new model



The entropy and energy density and pressure for iHQCD. The points come from lattice results.

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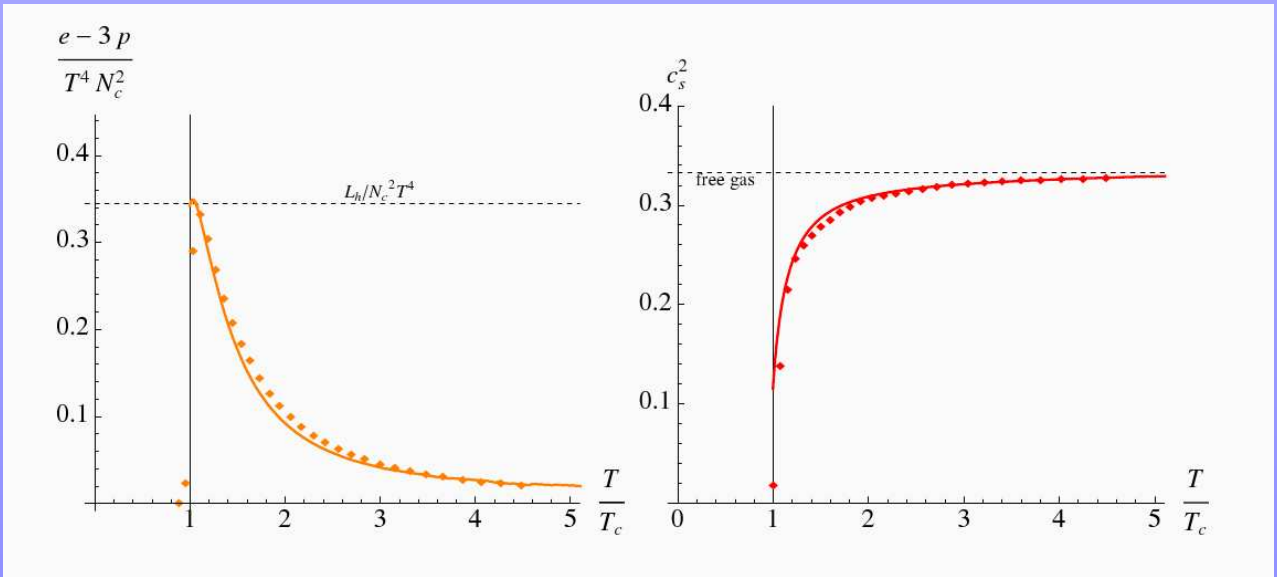
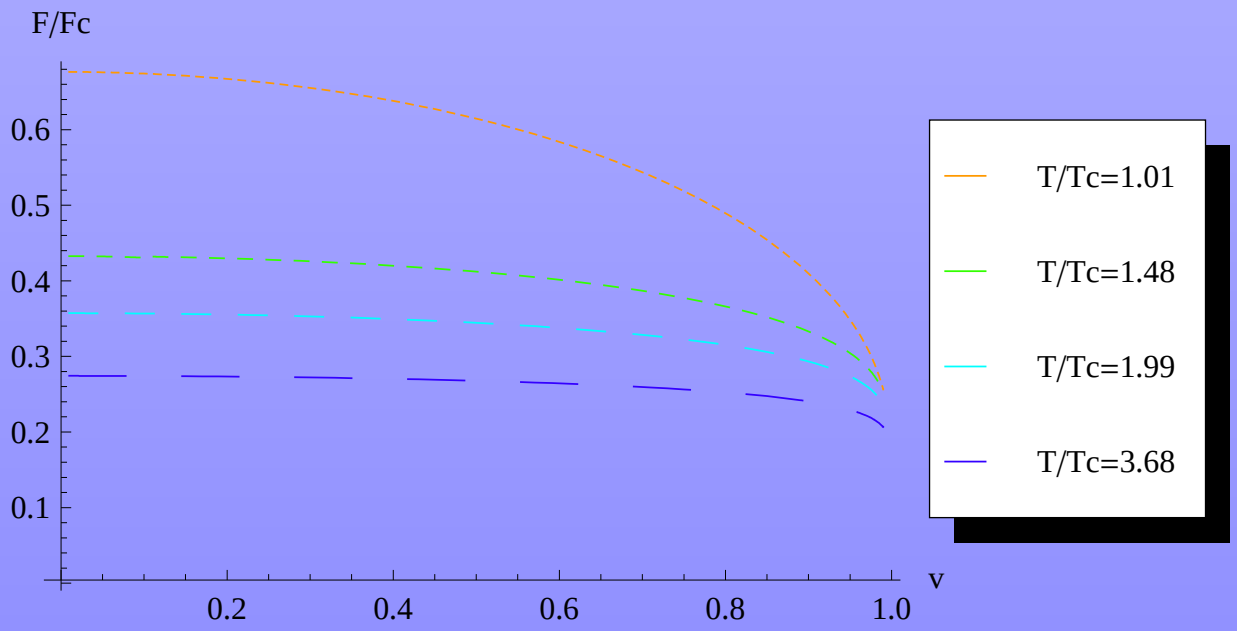


The conformal anomaly and the speed of sound for iHQCD. The points come from lattice results.

Drag force in iHQCD



The ratio of the drag force in iHQCD to the conformal $\mathcal{N} = 4$ SYM case is shown.

For high velocities and high temperatures asymptotic freedom becomes important. For $\mathcal{N} = 4$ SYM the 't Hooft coupling is chosen to be 6.

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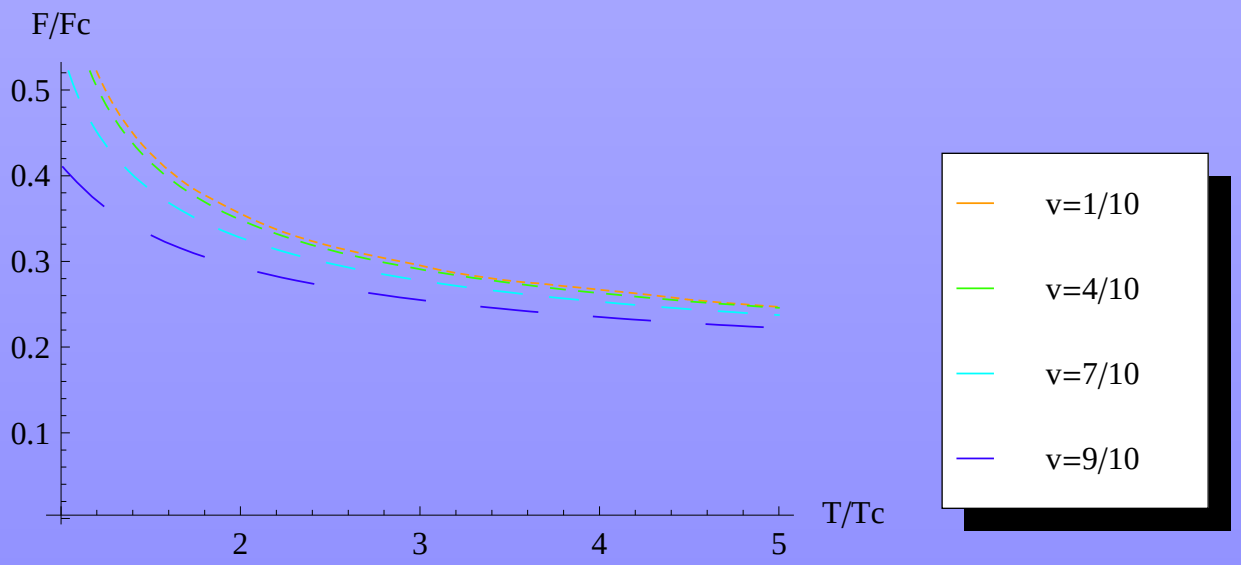

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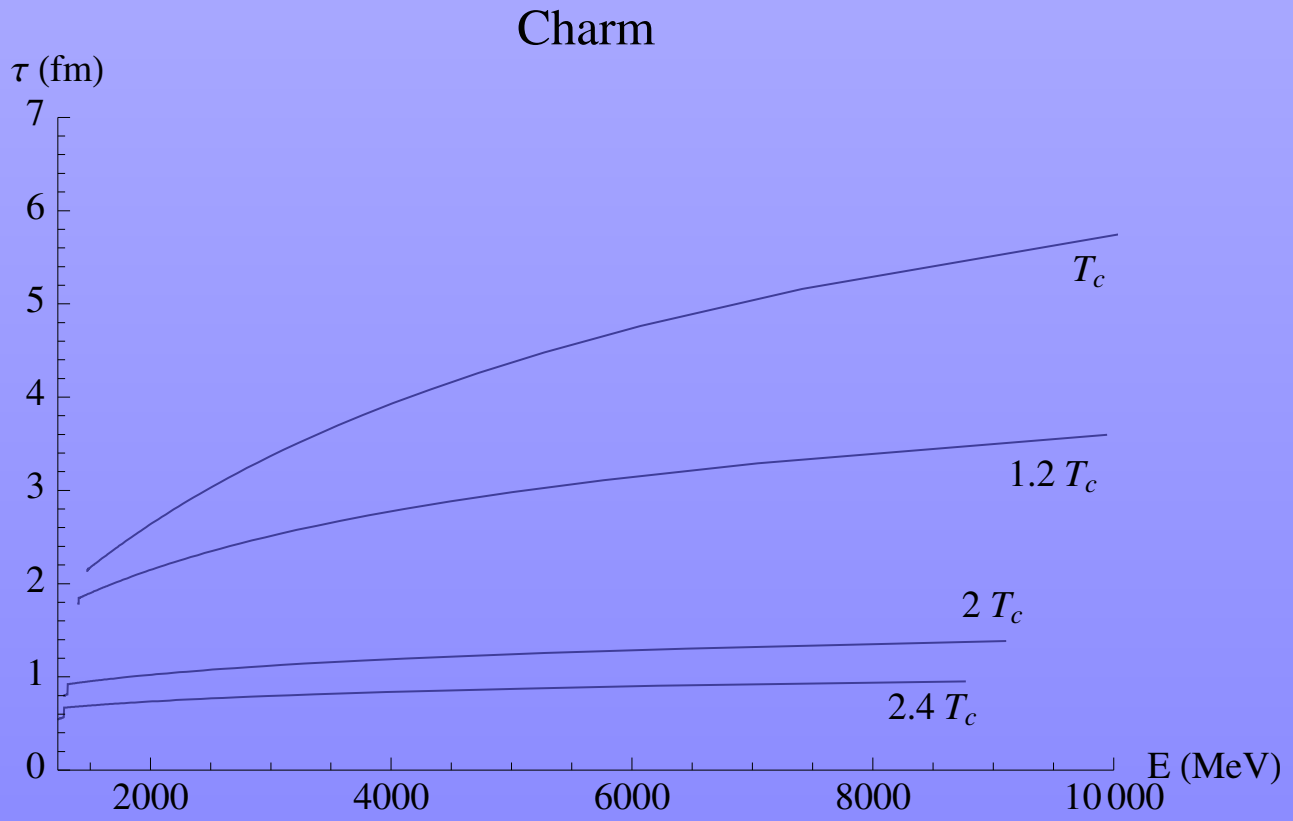
Diffusion in iHQCD

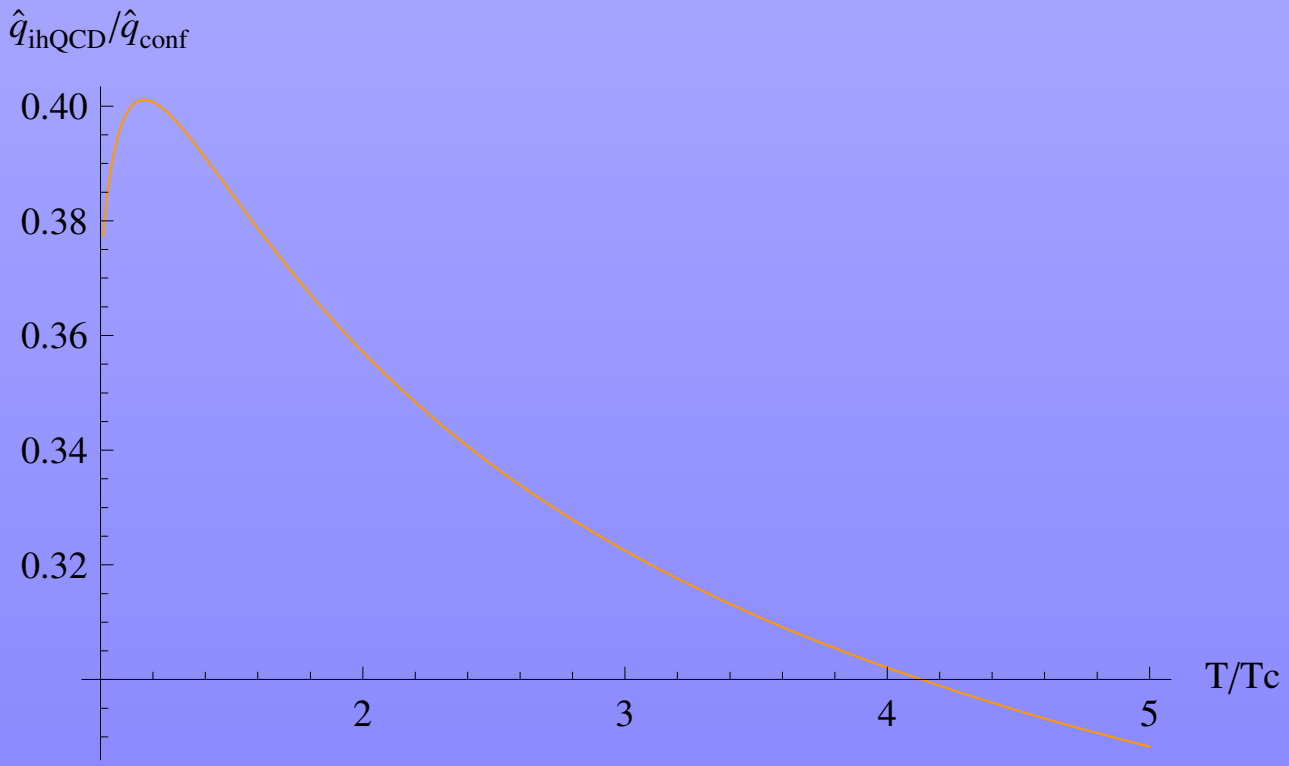


Diffusion time for the Charm quark, as a function of energy, for different ratios of the temperature to the IHQCD transition temperature Tc.

T, MeV	$T_{equiv.}$	T_{equiv}/T_C	τ_{diff} Charm	τ_{diff} Bottom
220	293	1.13	2.70 fm	8.64 fm
250	327	1.26	2.31 fm	7.04 fm
280	362	1.40	1.91 fm	6.09 fm
310	399	1.53	1.66 fm	5.31 fm
400	509	1.96	1.10 fm	3.51 fm
500	632	2.43	0.80 fm	2.56 fm

Table: In this table the diffusion times for the charm and a bottom quark are shown. Diffusion times have been evaluated at an energy of $E = 3 * M_q$ and at the equivalent temperature of the alternative scheme, shown in the third column.

Jet Quenching in iHQCD



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- Recent review arXiv:1101.0618