Correlation function of energy-momentum tensor in SU(3) gauge theory from gradient flow

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MK, T. Iritani, M. Asakawa, T. Hatsuda, to appear soon

EMT correlator

$$\langle T_{\mu\nu}(x) T_{\rho\sigma}(y) \rangle$$

Many useful info.

- thermodynamics
- transport properties
- etc.

Conserved channels

$$C_{\mu\nu;\rho\sigma}(\tau) = \frac{1}{T^5} \int d^3x \langle T_{\mu\nu}(\tau,\vec{x}) \bar{T}_{\rho\sigma}(0,\vec{0}) \rangle$$

$$\frac{\partial}{\partial\tau} C_{0\nu;\rho\sigma}(\tau) = 0 \Rightarrow \tau \text{ indep. const!}$$

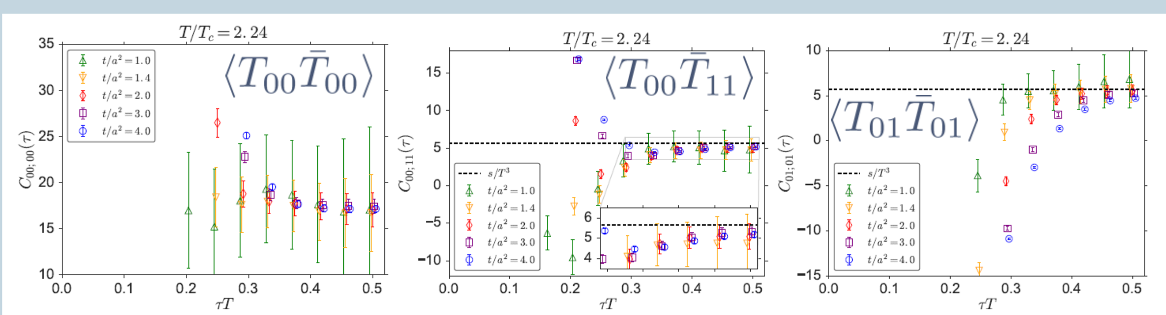
From linear response

$$C_{00;00}(\tau) = \frac{c_V}{T^3} \qquad C_{00;11}(\tau) = C_{01;01}(\tau) = \frac{\epsilon + p}{T^4}$$

⇒ **Check them on the lattice!**
New method for studying thermodynamics!

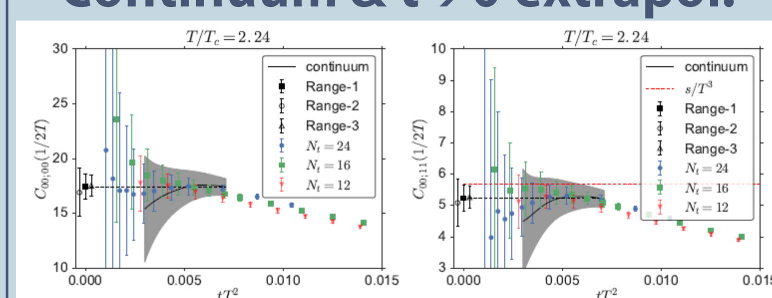
Numerical Results on quenched lattice

$T = 2.24 T_c$ $\quad \beta = 7.500,\ 96^3 \times 24$ $\quad \beta = 7.170,\ 64^3 \times 16$



- t indep. const. → confirmation of conservation law
- small error owing to gradient flow

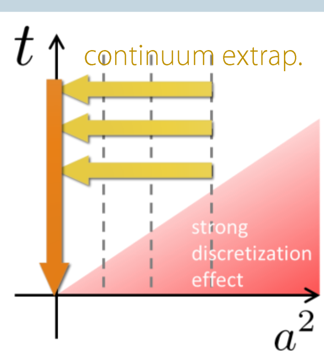
Continuum & t→0 extrapol.



$$\frac{c_V}{T^3} = 17.4(12)(25) \qquad \frac{s}{T^3} = 5.24(41)(81)$$

Summary

$$\begin{cases} C_{00;00}(\tau) = \dfrac{c_V}{T^3} & \text{new analysis of } c_V \\ C_{00;11}(\tau) = C_{01;01}(\tau) = \dfrac{\epsilon+p}{T^4} & \text{confirmed} \end{cases}$$



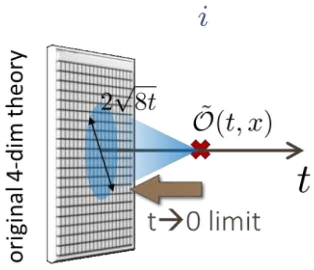
EMT on the lattice

- ☐ gradient flow

$$\partial_t A_\mu = D_\nu G_{\mu\nu} = \partial_\nu \partial_\nu A_\mu + \cdots$$

- ☐ small flow-time exp.

$$\tilde{O}(t,x) \longrightarrow \sum_i c_i(t) \mathcal{O}_i^R(x)$$



$$T^R_{\mu\nu}(x) = \frac{1}{\alpha_U(t)} U_{\mu\nu}(t,x) + \frac{\delta_{\mu\nu}}{4\alpha_E(t)} E(t,x)_{\text{subt.}} + O(t)$$

$$U_{\mu\nu}(t,x) = G_{\mu\rho}(t,x) G_{\nu\rho}(t,x) - \frac{1}{4}\delta_{\mu\nu} G_{\mu\nu}(t,x) G_{\mu\nu}(t,x)$$

$$E(t,x) = \frac{1}{4}\delta_{\mu\nu} G_{\mu\nu}(t,x) G_{\mu\nu}(t,x)$$

Suzuki, 2013

Thermodynamics FlowQCD, 2016