

Chiral magnetic effect & anomalous transport from real-time lattice simulations

M. Mace, N. Mueller, S. Schlichting, S. Sharma

Based on: N. Mueller, S. Schlichting and S. Sharma, arxiv:1606.00342 [hep-ph]
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XIIth Quark confinement and the Hadron Spectrum
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BROOKHAVEN
NATIONAL LABORATORY



UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386

Motivation

High-energy heavy-ion collisions provide an exciting environment to explore anomalous transport phenomena (c.f. talk by Kharzeev)

Chiral Magnetic Effect: $\vec{j}_v \propto j_a^0 \vec{B}$

axial charge density *magnetic field*

- *expect axial charge fluctuations due to sphaleron transitions*
- *strong magnetic field $eB \sim m_\pi^2$ present over the first ~ 1 fm/c*

Since life-time of magnetic field is short (~ 1 fm/c), expect that most of the effect take place during early-time pre-equilibrium stage

Goal: Develop theoretical description to study anomalous transport in out-of-equilibrium situations based on real-time lattice techniques

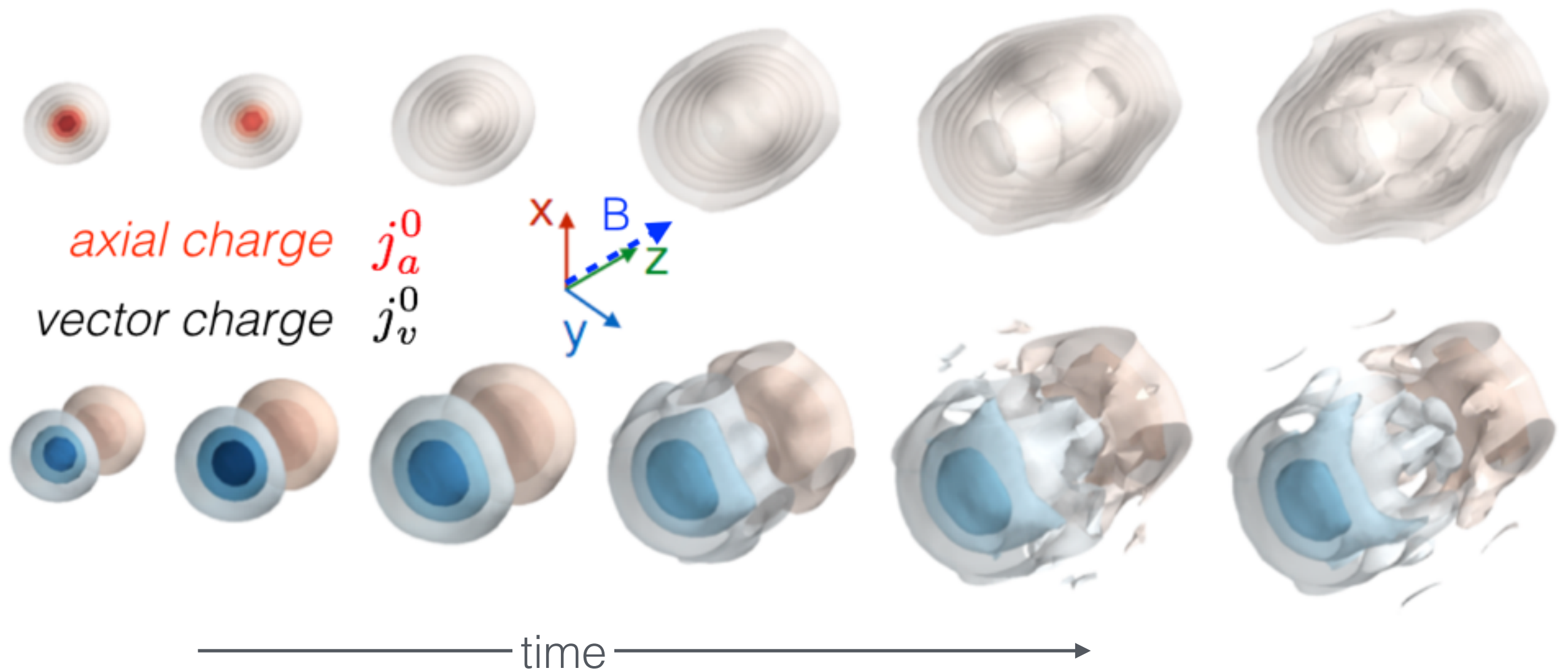
Simulation technique

Classical-statistical lattice gauge theory simulation with dynamical fermions

- Discretize theory on 3D lattice in the Hamiltonian formalism
- Solve operator Dirac equation on the operator level by mode function expansion $i\gamma^0 \partial_t \hat{\psi} = (-i\not{D}_W^s + m)\hat{\psi}$
- Compute vector and axial currents to study anomalous transport

-> Study dynamics of axial and vector charges during a SU(N) sphaleron transition in the presence of U(1) magnetic field

Chiral magnetic effect & Chiral magnetic wave



First time vector charge separation is established from real-time lattice simulations

Light quarks ($mt_{\text{sph}} \ll 1$)

Non-dissipative transport of axial and vector charges

Evolution at late times well described by anomalous hydrodynamics

Heavy quarks ($mt_{\text{sph}} \sim 1$)

Dissipation of axial charge leads to significant reduction of CME & CMW

Conclusions & Outlook

Developed an ab-initio approach to anomalous transport based on real-time lattice techniques

Quark-production & anomalous transport in heavy-ion collisions, Dirac semi-metals, ...

