Derivation of the Hydrodynamic Equation from the Quantum Transport Equation

Yuta Kikuchi (Kyoto Univ.)

collaborators

Teiji Kunihiro (Kyoto Univ.)
Kyosuke Tsumura (Fujifilm Corp.)
Kazuaki Ohnishi (Shinagawa, Tokyo)

Derivation of the Hydrodynamic Equation from the Quantum Transport Equation

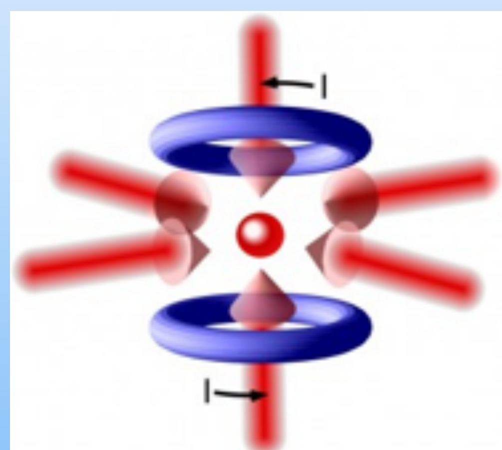
We are interested in the hydrodynamical analyses of the following two similar phenomena:

Derivation of the Hydrodynamic Equation from the Quantum Transport Equation

We are interested in the hydrodynamical analyses of the following two similar phenomena:

Unitary Fermi Gas

Hydrodynamical approach is useful



T. Schafer (2014)

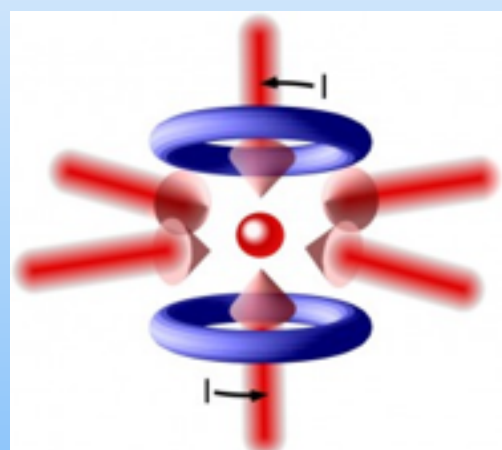
Problems

- Two regions: hydrodynamic core and dilute corona
- How to describe the transition between these region
- Consider a non-zero dissipative relaxation time

We are interested in the hydrodynamical analyses of the following two similar phenomena:

Unitary Fermi Gas

Hydrodynamical approach is useful



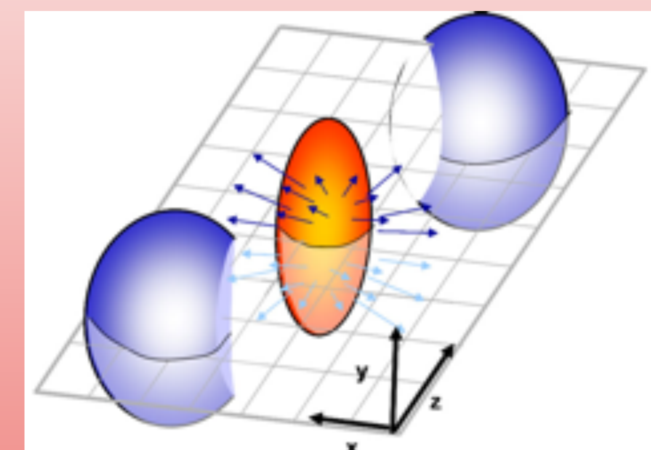
T. Schafer (2014)

Problems

- Two regions: hydrodynamic core and dilute corona
- How to describe the transition between these region
- Consider a non-zero dissipative relaxation time

Quark-Gluon Plasma

Relativistic analysis is needed



Fundamental problems

- Ambiguity in the definition of the flow velocity
- Unphysical instabilities of the equilibrium state
- Lack of causality

Derivation of the Hydrodynamic Equation from the Quantum Transport Equation

We are interested in the hydrodynamical analyses of the following two similar phenomena:

Unitary Fermi Gas

Hydroc

Problems

- Two regions: hydrodynamic core and dilute corona
- How to describe the transition between these region
- Consider a non-zero dissipative relaxation time

Quark-Gluon Plasma

eeded

Fundamental problems

- Ambiguity in the definition of the flow velocity
- Unphysical instabilities of the equilibrium state
- Lack of causality

Second Order (Mesoscopic) Hydrodynamic Equation is Needed!!

Derivation of the Hydrodynamic Equation from the Quantum Transport Equation

Hierarchy of Transport Equation

Microscopic transport equation
(e.g. Kadanoff-Baym equation)

↓ **coarse graining**

Kinetic equation
(e.g. Boltzmann equation)

↓ **coarse graining**

Hydrodynamic equation
(e.g. Navie-Stokes equation)

Relativistic or Non-Rel. -system

Classical or Quantum -system

Single or Multi -component

1st or 2nd -order hydro.

We derived 1st order hydrodynamic eq. in quantum multi-component system with the renormalization group method.

Derivation of the Hydrodynamic Equation from the Quantum Transport Equation

<u>Hierarchy of Transport Equation</u>

Microscopic transport equation
(e.g. Kadanoff-Baym equation)

coarse graining

Kinetic equation
(e.g. Boltzmann equation)

coarse graining

Hydrodynamic equation
(e.g. Navie-Stokes equation)

We want to derive

Relativistic or **Non-Rel.**
-system

Classical or **Quantum**
-system

Single or **Multi**
-component

1st or **2nd**
-order hydro.

We derived 1st order hydrodynamic eq. in quantum multi-component system with the renormalization group method.

Derivation of the Hydrodynamic Equation from the Quantum Transport Equation

Hierarchy of Transport Equation

Microscopic transport equation
(e.g. Kadanoff-Baym equation)

coarse graining

Kinetic equation
(e.g. Boltzmann equation)

coarse graining

Hydrodynamic equation
(e.g. Navie-Stokes equation)

We want to derive

Relativistic or **Non-Rel.**
-system

Classical or **Quantum**
-system

Single or **Multi**
-component

1st or **2nd**
-order hydro.

We derived 1st order hydrodynamic eq. in quantum multi-component system with the renormalization group method.