Round Table Transport Coefficients Report

It’s tough

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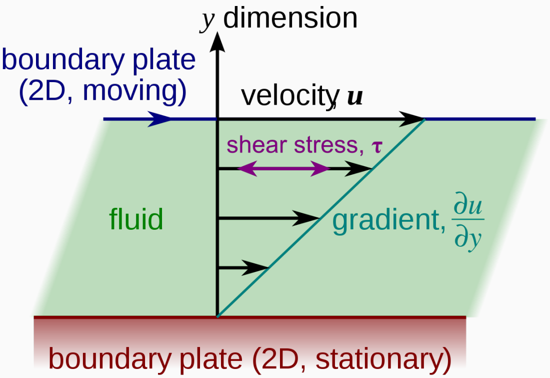
What are transport coefficients?

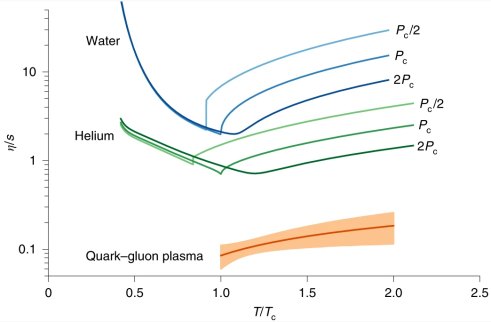
- Transport coefficients are a property of matter
- They encode the response of a system to small deviations from equilibrium
- Intuitive example from classical physics: Shear viscosity isotropizes speed gradient in viscous liquids



What transport coefficients are there?

- η: Shear viscosity, tendency of the fluid to resist changes in its shape or velocity gradient perpendicular to the direction of flow
- ζ: Bulk viscosity, describes the dissipative effects associated with changes in the fluid's thermodynamic pressure
- κ_{ij}: Diffusion coefficients/(cross) conductivities, describe how the medium reacts to an uneven distribution of charges or energy, or how charge currents affect each other
- Second order transport coefficients encode the reaction of the system to deviations that change with time

What do they depend on?



Bernhard et al.: Nature Phys. 15 (2019)

- From macroscopic fluids, we know that they can depend on temperature and density
- Additionally, the degrees of freedom and the nature of the interaction play a role too
- A minimum is expected near the phase transition

What ways do we use to learn about them?

- At high temperatures: perturbative QCD and Lattice QCD
- Around T_C: Lattice QCD
- Below T_C: Hadronic transport
- From experiment: usually includes contributions from all three ranges, needs to be carefully treated!

What we planned to talk about

- Introduction to each other's approaches on calculating/estimating transport coefficients
- Discuss which transport coefficients are the most interesting to compare to experiment
- Understand better the phenomenology
- Discuss how we can fix each others systematic uncertainties

How it went

- Spent way more time on learning from each others approaches than we planned. The approaches differ hugely.
- Hadronic transport has limited intersection with AMY and lQCD because low temperature regime is difficult to access by Lattice and not at all to pQCD
- Long discussion on spectral reconstruction by using kinetic theory input. This could give some idea about the functional form.
- How to renormalize Lattice correlators using gradient flow?

Questions that popped up

1. How does SMASH work?
2. How does HRG and SMASH compare?
3. Why is low energy regime difficult Lattice? How can we substract the UV part?
4. How can phenomenology profit from better theoretical knowledge about transport coefficients - and vice versa
5. How to understand intuitively the behaviour of diffusion coefficients in transport?
6. Why is there a peak in bulk viscosity/is bulk viscosity non-vanishing?
7. Which diffusion coefficients can we measure in experiment?
8. Is there reason to believe in a minimum of the shear viscosity and how does it extend into the (T, μ_B)-plane?
9. Do prediction from pQCD converge when going to higher order? Or can we go to higher order at all?

Input by PIs

- Spent a long time discussing these questions
- Got great support by Guy for some of the theoretical questions. Some things have better theoretical motivations, other are still unknown.
- Learnt from Tetyana that charm and charge diffusion coefficient are experimentally accessible , whereas baryon diffusion coefficient is very challenging
- We are grateful for the many inputs we received

Conclusion

- Round tables gave nice exposure to perspectives of researchers of different background/methods
- We explored the limits of our knowledge and of the knowledge of the community
- We enjoyed having sessions both with and without PIs
- The topic was due to its limited yet technical scope very challenging to tackle
- Unfortunately the table was not round, but rectangular