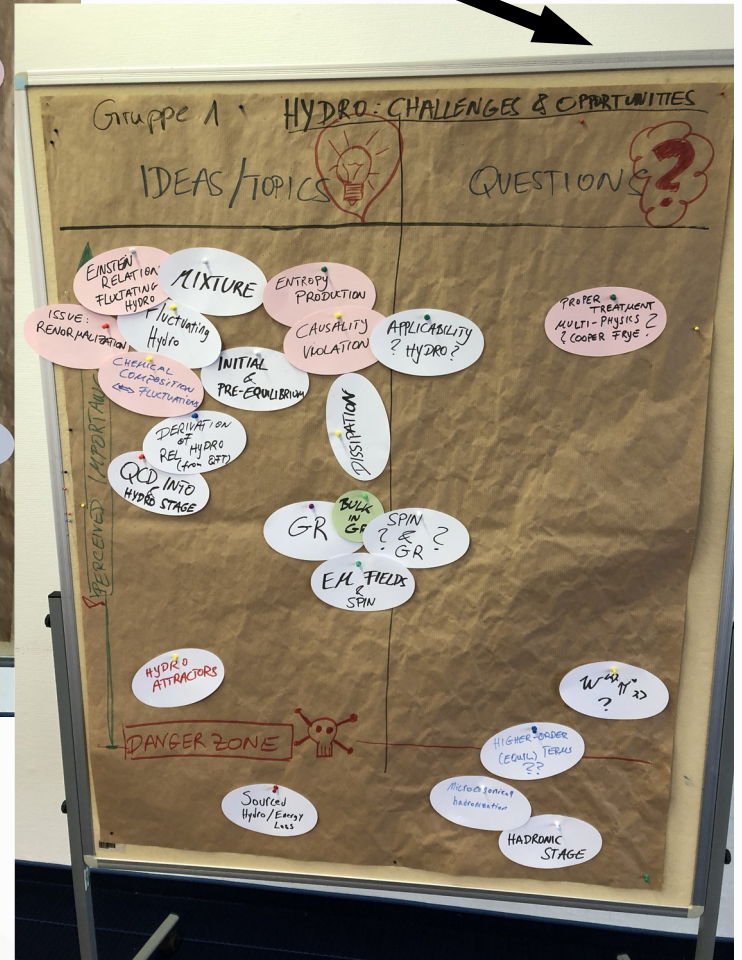
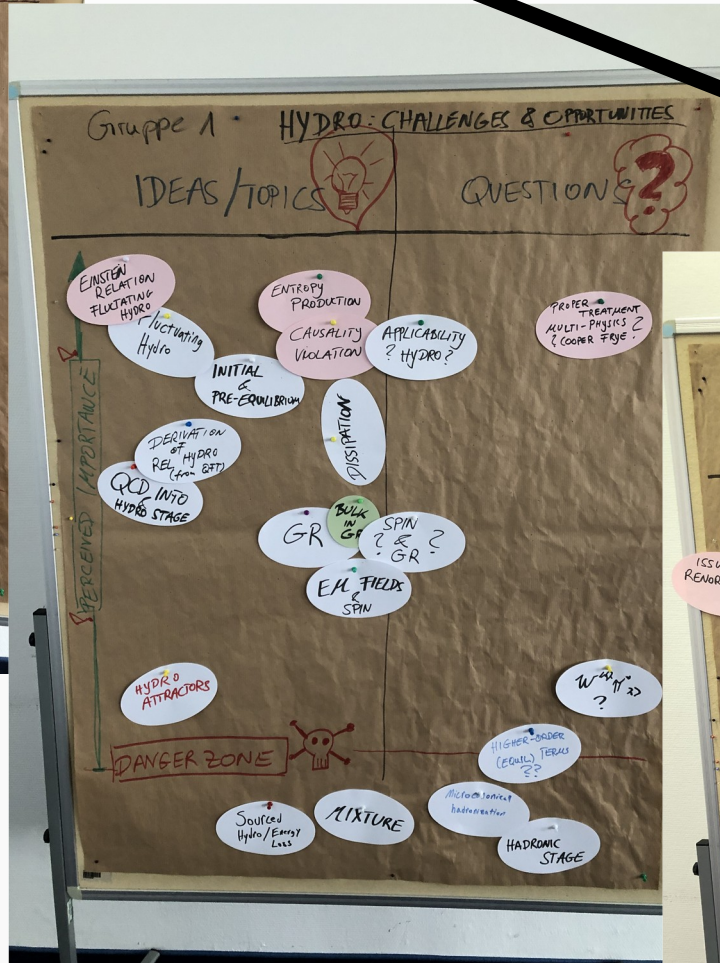
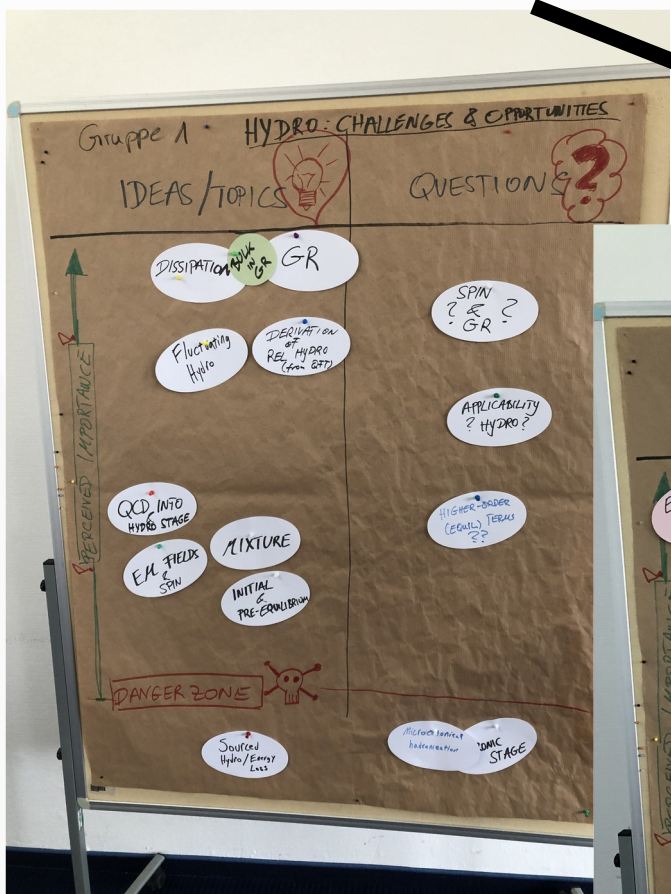


Report

Roundtable discussion

**Hydrodynamics:
Challenges and Opportunities**



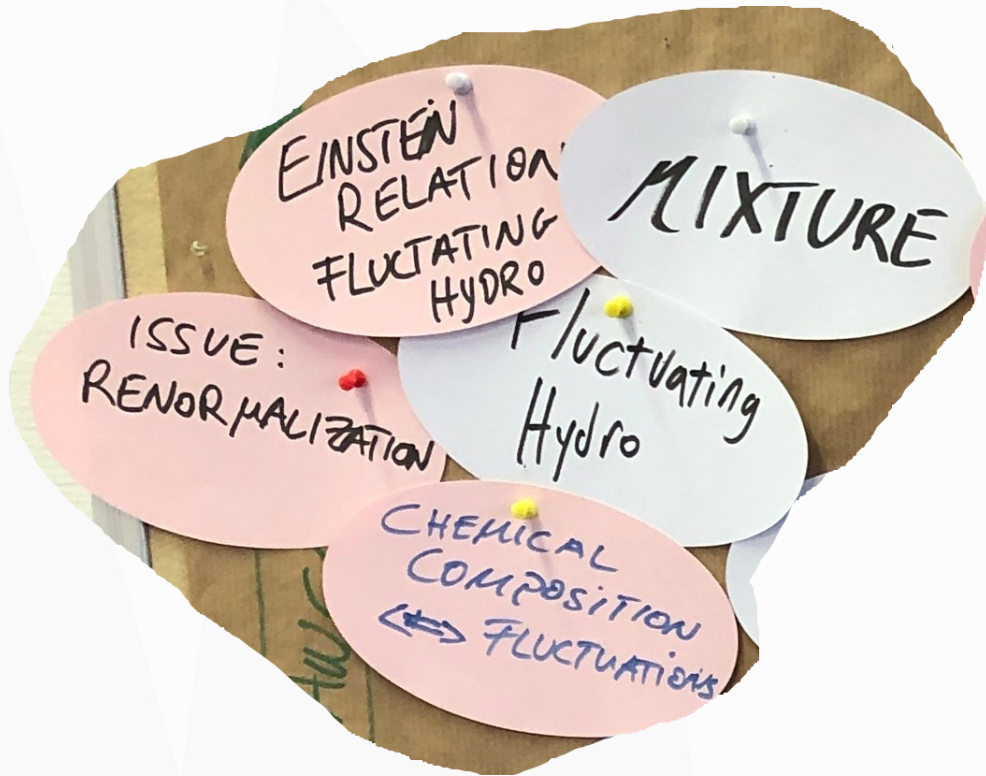
Evolution of ideas 

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Part I :
Main topics discussed

Fluctuating hydrodynamics



Motivation

- No feasible off-equilibrium description of QCD : use effective theories like hydro
- Thermal fluctuations significant in small systems
- Dynamic critical fluctuations

Discussions points

- Relativistic diffusive hydro with white noise
- Difference relativistic and non-relativistic Einstein relations?
- Possible future student projects? “Baby steps” instead of going big
- **Fluctuative coupled-charge transport in mixtures ↔ chemical composition**

Causality violation

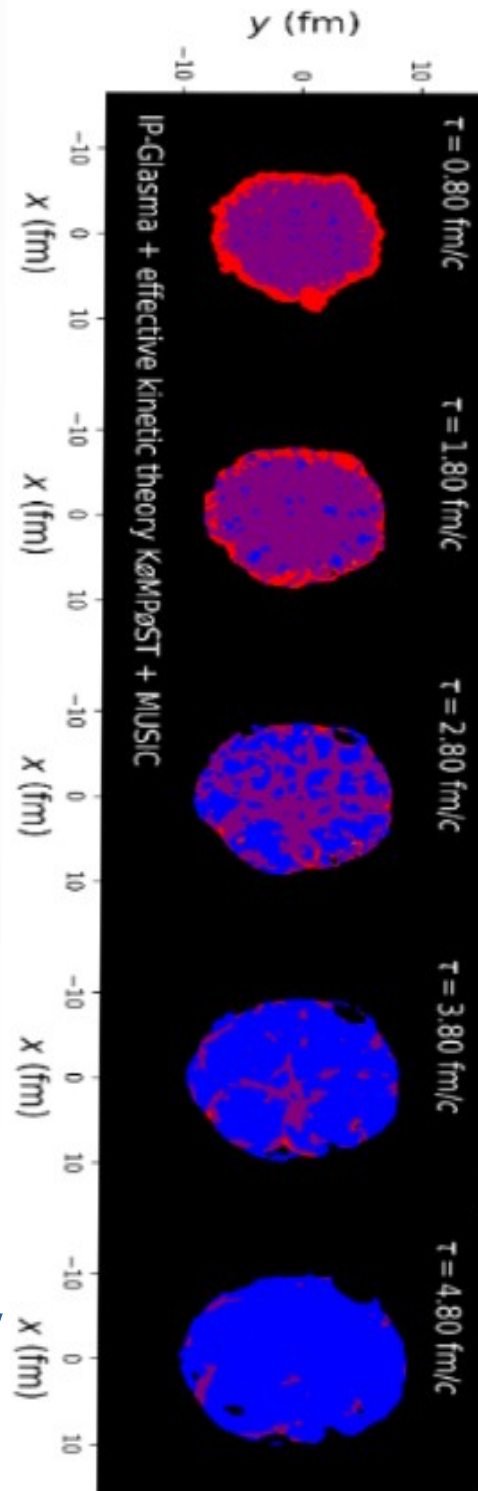


Discussions points

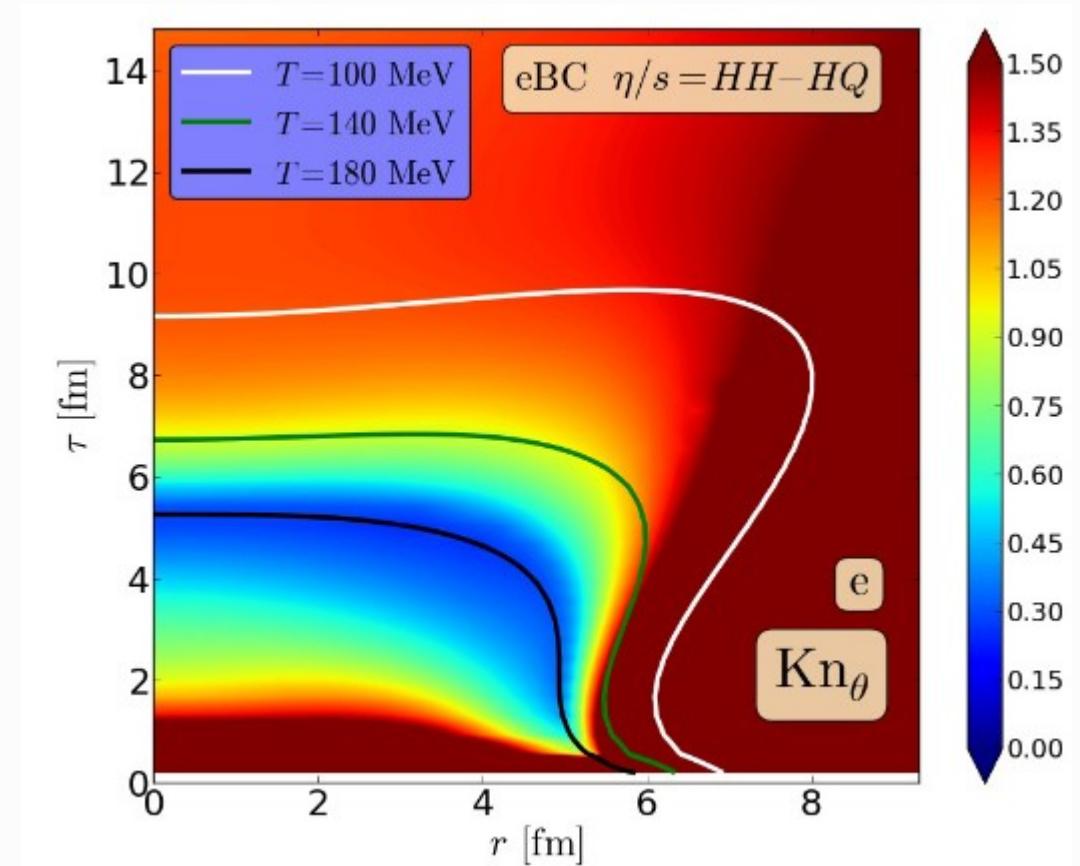
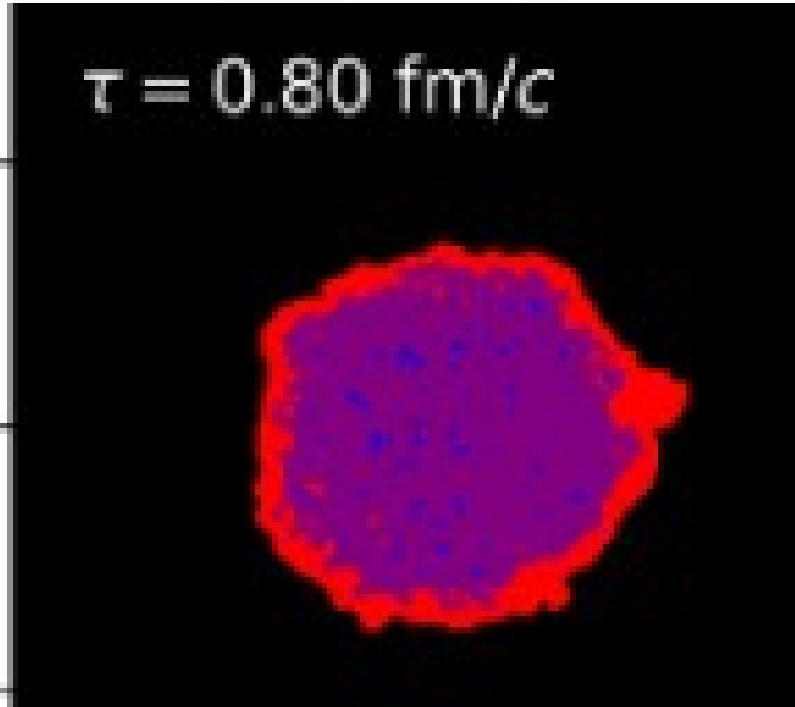
- Necessary and sufficient conditions for causality in hydro simulations
[Bemfica et al., PRL 126 \(2021\) 222301](#)
- Causality may be violated due to large initial gradients after switching to hydro
[Plumberg et al., PRC 105 \(2022\) L061901](#)
- Depends on pre-equilibrium model ↔ future: improve pre-equilibrium description
- Comparing analytic non-linear mode speeds with mode speeds used in numerics

Actionable!

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Concurrent off-equilibrium modeling



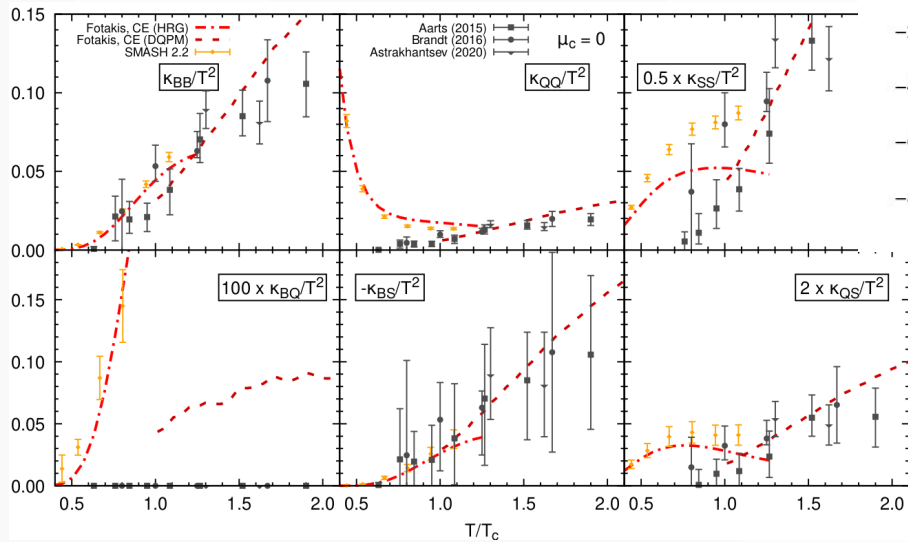
- Switching from pre-equilibrium to hydro, or from hydro to hadronic model bears caveats
- Strongly connected to applicability of hydro



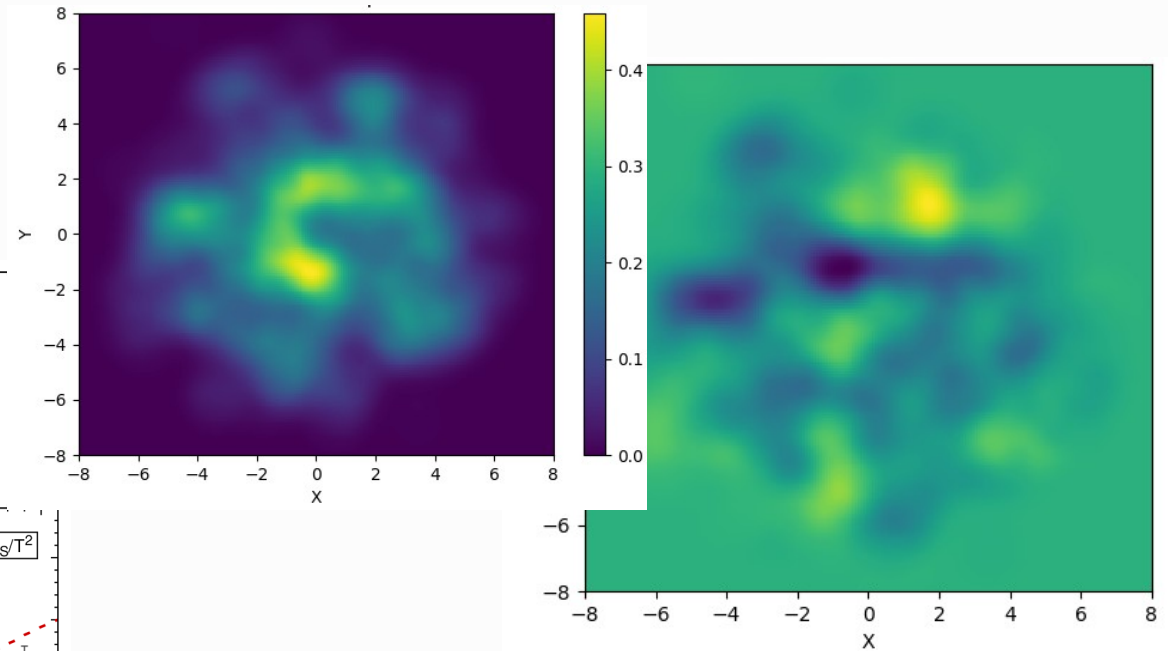
Part II :
**What we have wished to have more
time for**

Hydrodynamics of mixtures

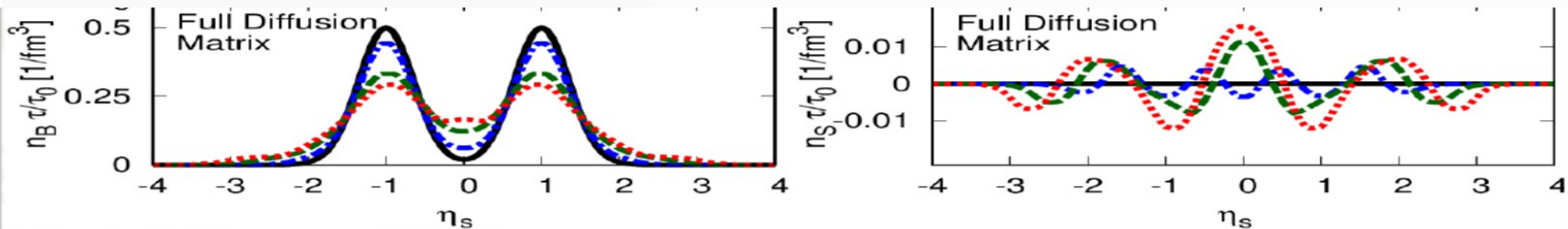
Transport coefficients (TraCoLinR)



Initial state (KoMPoST)

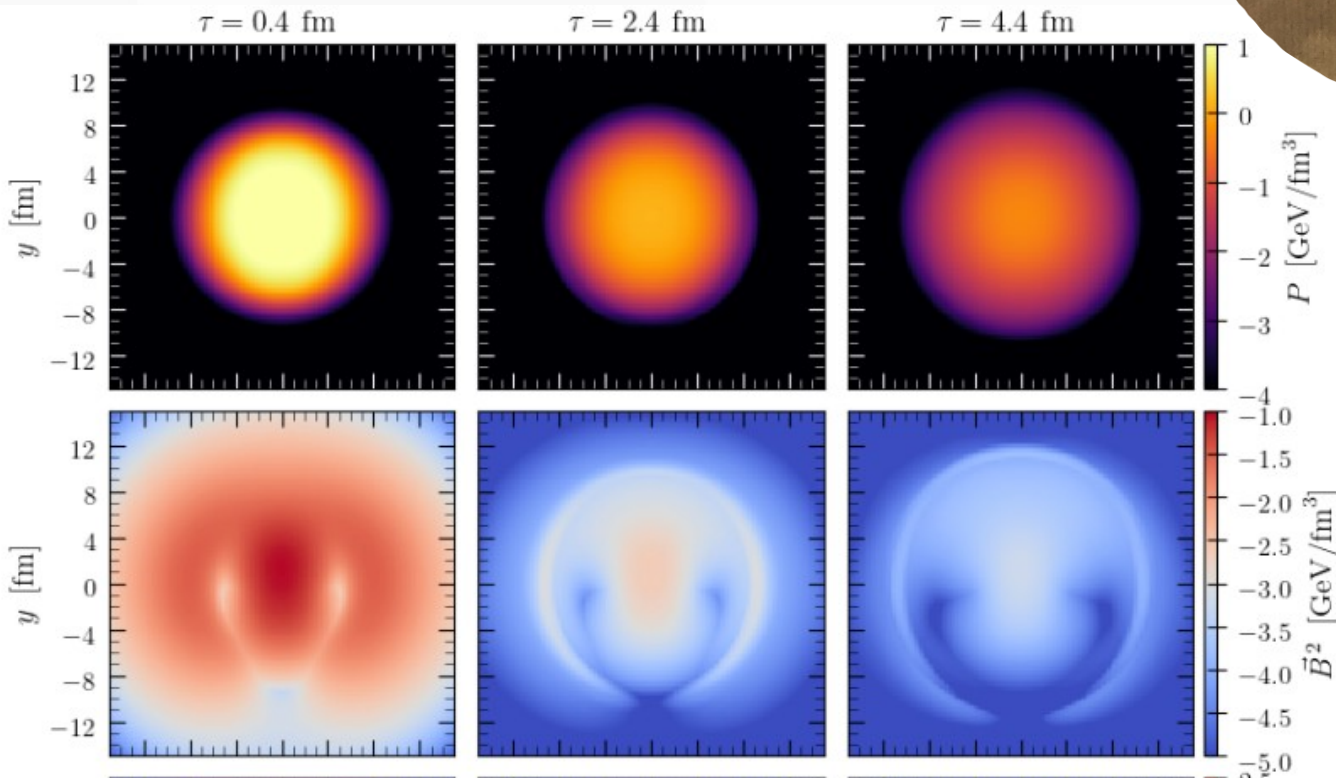


Coupled-charge transport (HYDRA)



EM fields, angular momentum, spin and general relativity

- Role of spin and magnetic fields in heavy-ion collision and compact stars (spin or magneto hydro dynamics)
- Hyperon polarization \leftrightarrow CME
- Spin \leftrightarrow spacetime torsion



- Turbulence during heavy-ion collision?
- Higher-order vorticity terms of rotating systems in equilibrium

Transient relativistic hydrodynamics from quantum field theory?

Relativistic hydrodynamics from quantum field theory
on the basis of the generalized Gibbs ensemble method

Tomoya Hayata

