

Derivation of Causal Relativistic Hydrodynamic Equations and Novel Moment Method

This is an extension of our previous work[1,2] to the derivation of the causal relativistic hydrodynamic equations in generic local rest frames for a viscous fluid from the relativistic Boltzmann equation. Our derivation is based on the renormalization group method[3] as a powerful reduction theory of the dynamics. We have identified some drawbacks in our previous derivation of the causal equations[4]. Our improved equation is a natural extension of the first-order equation derived by the present authors.[1] The relaxation times derived in our microscopic theory have forms which can be nicely interpreted in terms of correlation functions. Our equation in any local rest frame including the particle frame has a definite stable thermal equilibrium state and is completely free from the instability problem. Our equation in the energy-frame is found quite different from the one by Denicol et al [5] which is derived on the basis of a moment method; but our equation can be well approximated by it when the Rits approximation is valid for a rarefied gas. On the basis of our derivation, we propose the correct moment method for the derivation of causal hydrodynamic equations without ad-hoc ansatz.

References

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