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Dissipative effects in ultrarelativistic kinetic theory

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The equations of relativistic hydrodynamics can be obtained from the Boltzmann equation via the Chapman-Enskog (CE) procedure and Grad's 14 moments approximation. These approaches give different results for the transport coefficients, which reduce to the same expressions in the non-relativistic limit.

In this contribution, the propagation of a harmonic longitudinal wave is considered in the frame of the first- and second-order relativistic hydrodynamics theories. The ensuing hydrodynamic equations are solved in the linearized regime (valid for small wave amplitudes). The analytic solutions corresponding to the CE and Grad transport coefficients are compared to the numerical solution of the relativistic Boltzmann equation for massless particles in the Anderson-Witting (AW) approximation, obtained using the lattice Boltzmann (LB) method. The comparison clearly confirms the validity of the CE prediction.

For particular initial conditions, the first-order formulation gives incorrect predictions for the wave evolution even when the AW relaxation time is small. This is remedied in the second-order formulation, the solution of which is confirmed by numerical simulations.

Content type

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