General Relativity and Quantum Cosmology

# Causal Relativistic Fluid Dynamics

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We derive causal relativistic fluid dynamical equations from the relaxation model of kinetic theory as in a procedure previously applied in the case of non-relativistic rarefied gases. By treating space and time on an equal footing and avoiding the iterative steps of the conventional Chapman-Enskog --- CE---method, we are able to derive causal equations in the first order of the expansion in terms of the mean flight time of the particles. This is in contrast to what is found using the CE approach. We illustrate the general results with the example of a gas of identical ultrarelativistic particles such as photons under the assumptions of homogeneity and isotropy. When we couple the fluid dynamical equations to Einstein's equation we find, in addition to the geometry-driven expanding solution of the FRW model, a second, matter-driven nonequilibrium solution to the equations. In only the second solution, entropy is produced at a significant rate.

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