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Shear viscosity and resonance lifetimes in the hadron gas

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Previous calculations of the shear viscosity to entropy density ratio in the hadron gas have failed to reach a consensus, with η/s predictions differing by almost an order of magnitude. This work addresses and solves this discrepancy by providing an independent extraction of this coefficient using the newly-developed SMASH (Simulating Many Accelerated Strongly interacting Hadrons) transport code and the Green-Kubo formalism. We compare the results from SMASH with numerical solutions of the Boltzmann equation for various systems using the Chapman-Enskog expansion as well as previous results in the literature. Substantial deviations of the coefficient are found between transport approaches mainly based on resonance propagation with finite lifetime (such as SMASH) and other (semi-analytical) approaches with energy-dependent cross-sections, where interactions do not introduce a timescale other than the inverse scattering rate. Our conclusion is that long-lived resonances strongly affect the transport properties of the system, resulting in significant differences in η/s with respect to other approaches where binary collisions dominate. We argue that the relaxation time of the system —which characterizes the shear viscosity—is determined by the interplay between the mean-free time and the lifetime of resonances. We finally show how an artificial shortening of the resonance lifetimes or the addition of a background elastic cross section nicely interpolate between the two discrepant results. To turn this around, we finally note that the temperature dependence of η/s can be used to constrain the properties of the hadron gas.

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