Comment on "Is There a 'Most Perfect Fluid' Consistent with Quantum Field Theory?"

Recently, Cohen [1] sketched a clever construction which seems to invalidate the conjectured viscosity bound [2] while remaining within the domain of well-defined relativistic quantum field theories. The example involves a metastable gas of heavy-light mesons in a gauge theory with a large number of colors and flavors. Here we note that in the example of Ref. [1], the viscosity and the entropy density exist in nonoverlapping length-scale regimes. Hence the system does not constitute a counterexample to the viscosity bound, as claimed in Ref. [1], if one makes a reasonable assumption that the viscosity and the entropy density exist in the same physical regime.

In fact, the lifetime of this metastable system, as noted in Ref. [3], may scale as a power of ξ in the limit $\xi \to \infty$, in unit of the time a meson travels the mean interparticle separation. It is due to the recombination of $O(1)$ particles into a bound cluster. One the other hand, the number of flavors scales as $\exp(\xi^4)$. The entropy density is a sensible concept only in a volume which contains all particle species, which means that the linear size of the volume has to be larger than $\exp(\frac{1}{3}\xi^4)$, in unit of the interparticle separation. Any measurement of the viscosity over such a long distance will take much longer than the lifetime of the system.

The example constructed in Ref. [1] is a remarkable system where the hydrodynamic regime is achieved at a distance where the thermodynamic limit is still far from being reached. One seems unable to measure the viscosity over distance scales associated with the thermodynamic limit. It seems reasonable, thus, to refrain from applying the viscosity bound to such a system.

It remains true that within nonrelativistic quantum mechanics (without being concerned about relativistic completion) one can evade the viscosity bound by increasing the number of particle species [1,2].

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