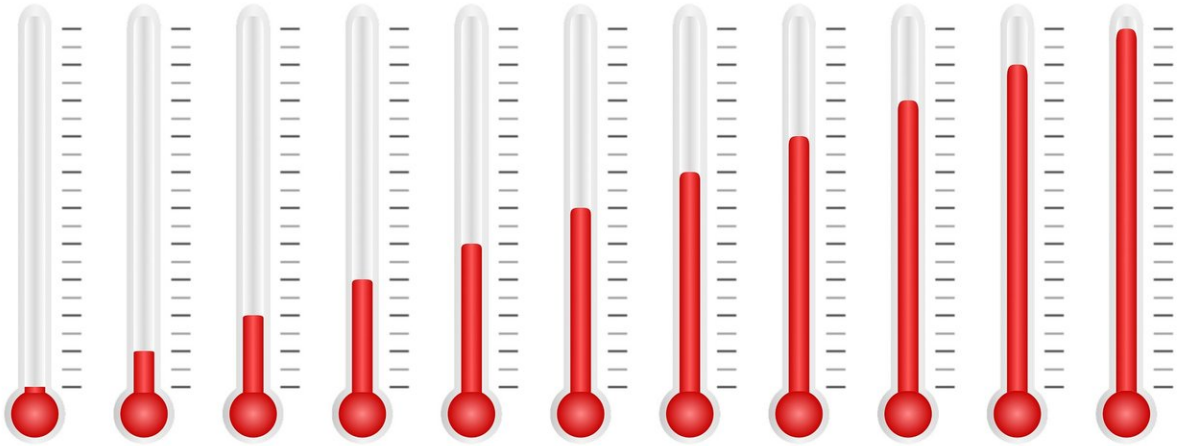
Effective temperatures connect equilibrium and nonequilibrium systems

August 12 2021, by Li Yuan



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What is temperature? A direct understanding of temperature is the specific number shown on thermometers. A much more scientific definition of temperature is a statistical concept in equilibrium systems. However, what about nonequilibrium systems?

Nonequilibrium systems are characterized by time evolution, so the application of the traditional statistical method is deviated, resulting in several different effective temperatures.

Recently, a team led by Prof. Xu Ning from University of Science and

Technology of China (USTC) of the Chinese Academy of Sciences (CAS) proposed a novel way to understand what "effective temperature" really represents. They suggested that effective temperature is consistent with the characteristic temperature of the corresponding equilibrium system.

This work was published in *Science Advances*.

The researchers focused on the temperature derived from the fluctuation-dissipation relations (FDRs). After developing a new module, they implemented the calculation of density correlation and response of inherent structures, and then derived TIS from the ratio.

What surprised the researchers was that TIS highly corresponded to the crystallization temperature of mono-component systems and the onset temperature of glass-formers, both of which are characteristic temperatures in equilibrium system. This consistency bridges nonequilibrium and equilibrium systems and indicates the equivalency of crystallization temperature and onset temperature.

Moreover, they directly calculated the effective temperatures for aging glasses and quasi-static flows of sheared and self-propelled systems.

Results showed that the effective temperature of nonequilibrium system was in agreement with the characteristic temperature of the corresponding equilibrium system. The researchers explained the widely used effective temperature in nonequilibrium system and indicated an indirect way to obtain characteristic temperatures of equilibrium systems.

More information: Jianhua Zhang et al, Unifying fluctuation-dissipation temperatures of slow-evolving nonequilibrium systems from the perspective of inherent structures, *Science Advances* (2021). DOI:

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