Sublinear drag regime at mesoscopic scales in viscoelastic materials

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Abstract

One of materials science's theoretical challenges is linking the physical mechanisms at the microscale to macroscopic functional behavior. It is well-known that mesoscale interactions play an essential role in soft matter, which is responsible for material softness. The origins of such rheological behavior need to be better investigated. Concerning the viscoelastic properties of materials, there are two major types of relaxations: exponential and power-law. Exponential materials can be modeled by associations of hookean springs and dashpots, while power-law materials are usually described by fractional calculus [1] or by the soft-glassy rheology models [2]. However, these models cannot explain the microscopic origins of such macroscopic responses. Here, we designed a computational model of viscoelastic materials composed of an immersed elastic network where non-linear hydrodynamic drag forces control the macroscopic viscoelasticity. We perform indentation experiments onto the network using molecular dynamics and reproduce materials with diverse viscoelastic signatures. Our findings show that in materials not too soft, not too elastic, the type of relaxation is entirely controlled by the exponent of the sublinear drag force.

References

[1] B. J. West, M. Bologna, and P. Grigolini, Physics of Frac- tal Operators (Springer, 2003).
[2] Fabry, B. et al., Scaling the microrheology of living cells, Phys. Rev. Lett. 87, 148102 (2001).

Figures

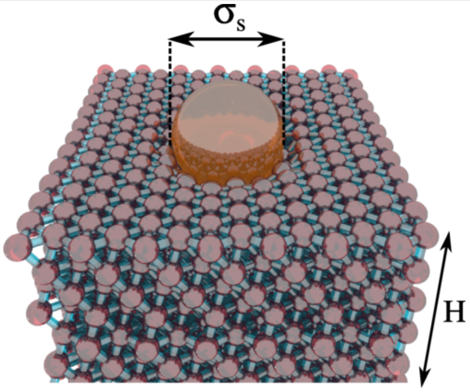

Figure 1: Schematics of a nanoindentation experiment in a computational viscoelastic body.