Master 2 Internship

Title: Understanding Confined Glass Transition using Levitodynamics

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Project:

According to Anderson, the most profound and interesting problem in condensed matter physics is the glass transition. Indeed, glassy materials are ubiquitous in nature, and discussions of the glass transition involve many areas of physics. Despite intense interest in the dynamic slowing down that accompanies glass formation, a complete microscopic theory does not yet exist. Recently, the supposed existence of a length scale ξ for cooperative rearrangement has generated considerable interest in an alternative approach: the study of confined glasses. The correlation length scales emerging in these systems appear to be much larger than molecular sizes, which intrigues the community. We propose to address the problem of confined glass transition on a silica nanoparticle isolated from its environment using optical trapping in vacuum.

The proposed method involves significantly modifying/improving an experimental system [1,2,3] whose basis has already been developed at LOMA for other fields of application. The originality of our new device is that it will enable independent determination of the size, refractive indices (real and imaginary) and temperature of a glass former nanoparticle optically trapped at a wavelength of 1064 nm [4,5]. The addition of an extra CO_2 laser will enable us to finely control the temperature of the nanoparticle whose position is resolved in 3D using ultra fast interferometric detection [1,5]. We will then be able to measure in situ changes in expansion coefficients and indices [2], and deduce the glass transition temperature of a synthesized [4,5] single glass former nanoparticle as a function of its radius. These results will then be analyzed in the context of the team's recent theoretical predictions for fragile glasses suggesting a crucial role of cooperative effects and surface mobility [6,7].

[1] Y. Amarouchene, L. Ondic, M. Mangeat, T. Guerin, D.Dean and Y. Louyer, *Nonequilibrium dynamics induced by scattering forces for optically trapped nanoparticles in strongly inertial regimes.* Phys. Rev. Lett. 122, 183901 (2019).
[2] M. Lavaud, T. Salez, Y. Louyer, and Y. Amarouchene, *Stochastic inference of surface-induced effects using Brownian motion.* Phys. Rev. Res. 3, L032011 (2021).
[3] A, Alexandre, M, Lavaud, N, Fares, E, Millan, Y, Louyer, T. Salez, Y. Amarouchene, T, Guerin, and D. S. Dean, *Non-Gaussian Diffusion Near Surfaces.* Phys. Rev. Lett. 130, 077101 (2023).
[4] J. Millen, T. Deesuwan, P. Barker, and J. Anders, *Nanoscale temperature measurements using nonequilibrium Brownian dynamics of a levitated nanosphere*, Nat. Nanotechnol. 9, 425 (2014).
[5] E Hebestreit, R Reimann, M Frimmer and L Novotny, *Measuring the internal temperature of a levitated nanoparticle in high vacuum*, Phys. Rev. A. *97, 4 043803* (2018).
[6] M. Arutkin, E. Raphael, J. A. Forrest, and T. Salez. *Cooperative strings in glassy nanoparticles.* Soft. Matter. 13, 141 (2017).
[7] T. Salez, J. D. McGraw, K. Dalnoki-Veress, E. Raphael, and J. A. Forrest. *Glass transition at interfaces.* Eur. Phys. News. 48, 24 (2017).