Master 1/2 Internship

Title: **Exploring the Frontiers of Condensed Matter Physics: Investigating the Glass Transition in Confined Silica Nanoparticles**

Type: experimental

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PhD funding (if any): Yes

Project:

Condensed matter physics offers a rich tapestry of intriguing phenomena, with the glass transition standing out as one of the most profound and captivating problems. Glassy materials, pervasive in the natural world, evoke complex discussions that transcend multiple domains of physics. Despite the fervent pursuit of understanding the dynamic slowing down accompanying glass formation, a comprehensive microscopic theory remains elusive. Recent attention has centered on the concept of a cooperative rearrangement length scale, denoted as ξ, which has sparked considerable interest in a novel approach— the study of confined glasses. These systems exhibit correlation length scales that surpass molecular dimensions, igniting curiosity within the scientific community.

Our proposal seeks to tackle the enigma of the confined glass transition by isolating a silica nanoparticle within a vacuum using optical trapping. This pioneering method builds upon an established experimental foundation developed at LOMA for various applications, but it distinguishes itself by allowing independent determination of the size, optical index (both real and imaginary), and temperature of a silica nanoparticle trapped optically at a wavelength of 1064 nm. The integration of an additional CO_2 laser, a vital component of this project, empowers precise control over the nanoparticle's temperature. This, combined with the nanoparticle's 3D position resolution through ultrafast interferometric detection, and the use of state of art Lorenz-Mie Holography equips us to measure in situ variations in expansion coefficients and optical index. Consequently, we hope to deduce the glass transition temperature of a single silica nanoparticle in relation to its radius. These groundbreaking results will be analyzed within the framework of recent theoretical predictions by our research team.

References :

-Supercooled liquids and the glass transition, Debenedetti, P., Stillinger, F. Nature **410**, 259–267 (2001).
-Facets of glass physics, Ludovic Berthier, Mark D. Ediger; Physics Today 1 69 (1): 40–46. (2016),
-Glass transition at interfaces Thomas Salez, Joshua D. McGraw, Kari Dalnoki-Veress, Elie Raphaël and James A. Forrest Europhysics News 48/1, 69 (1): 40–46 (2017).
-Nonequilibrium Dynamics Induced by Scattering Forces for Optically Trapped Nanoparticles in Strongly Inertial Regimes Yacine Amarouchene, Matthieu Mangeat, Benjamin Vidal Montes, Lukas Ondic, Thomas Guérin, David S. Dean, and Yann Louyer Phys. Rev. Lett. 122, 183901 (2019).
-Stochastic inference of surface-induced effects using Brownian motion Maxime Lavaud, Thomas Salez, Yann Louyer, and Yacine Amarouchene Phys. Rev. Research 3, L032011 (2021).
-Giant Diffusion of Nanomechanical Rotors in a Tilted Washboard Potential L. Bellando, M. Kleine, Y. Amarouchene, M. Perrin, and Y. Louyer Phys. Rev. Lett. 129, 023602 (2022).