

PhD Research Proposal Form China Scholarship Council (CSC) - ENS Group

FIELD: Physics & Engineering

Thesis subject title: **Direct measurements of frozen-in stresses in colloidal gels**

Name of the French doctoral school: ED 52 PHAST, Physique et Astrophysique

Name of the Research team: Soft Matter team / Divoux Lab

Website: <https://www.divouxlab.cnrs.fr/>

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Lab Language: English & French

Research Proposal Abstract: Colloidal gels are crucial in biological networks, cell mechanics, food science, and building materials [1]. They result from the aggregation of sub-micron particles such as polysaccharide coils, actin filaments, attractive globular proteins, or cement particles, forming a percolated network that confers solid-like properties under small deformations.

In addition, these gels display remarkable nonlinear behavior featuring stress- or strain-stiffening and fractures before irreversible rupture [2,3]. Recent experiments have shown that the frozen-in stresses that develop during the sol-gel transition strongly impact the nonlinear response of these gels [4]. However, these internal stresses were only evidenced indirectly at the macroscale. Moreover, there is no clear link between the microscale stress heterogeneities inside a colloidal gel and its macroscopic failure time.

The Thesis aims to make the handshake between the frozen-in stresses at the microscopic scale and the gel nonlinear mechanical response at the macroscale. In practice, the candidate will measure the local mechanical properties of colloidal gels using atomic force microscopy and a state-of-the-art nano-indenter (Optics 11) to quantify the frozen-in stresses. Subsequent creep experiments with larger diameter probes ($\sim 100\mu\text{m}$) will allow measuring the nonlinear gel response on these regions of interest and link the frozen-in stresses with the failure scenario.

References :

- [1] Zaccarelli, J. *Phys.: Condens. Matter* **19**, 323101 (2007)
- [2] Leocmach, Perge, Divoux & S. Manneville, *Phys. Rev. Lett.* **113**, 038303 (2014)
- [3] Gibaud, Divoux & S. Manneville, In: Meyers R. (eds) *Encyclopedia of Complexity and Systems Science*. Springer, Berlin, Heidelberg (2020)
- [4] Pomella, Cipelletti & Ramos, *Phys. Rev. Lett.* **125**, 268006 (2020)

Type of PhD :

1.Full PhD

- Joint PhD/cotutelle (leading to a double diploma) : NO
- Regular PhD (leading to a single French diploma) : YES

2. Visiting PhD (for students enrolled at a Chinese institution who will be invited to a French institution to carry out a mobility period) :

NO