3 Postdoctoral research positions. Friction in fabrics, knits and ropes.

Context: Natural fibers (cotton fibers, hemp, ...) or yarns (polymer filaments, staple yarns) can be assembled to form materials with interesting mechanical properties. Knitted fabrics, for example, are periodical structures of interlocking fibers that are extremely deformable, even though the individual threads are almost inextensible. Another example is metallic cables, which may be easily bent, while rods of the same cross-section made with the same material are extremely rigid. Solid friction forces between fibers or wires play a fundamental role in these systems. They oppose fiber slippage and tend to increase the "cohesion" between the fibers. They also have a tendency to stiffen the system. We are interested in the effect of solid friction forces between yarns or fibers on mechanical properties in model systems of knit fabrics or ropes.

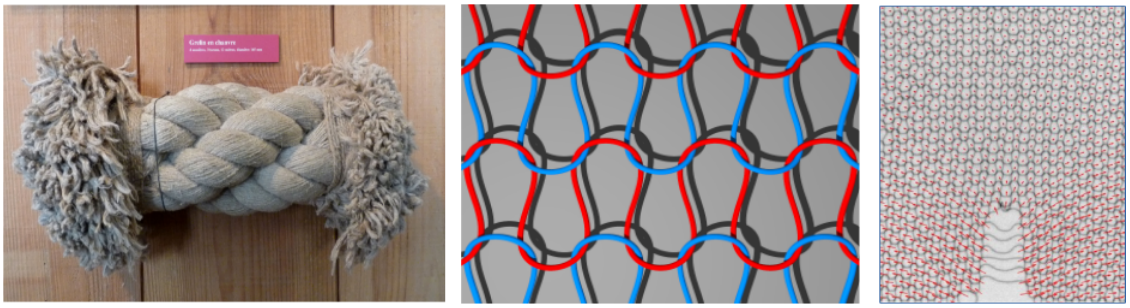

Figure 1: (left): A rope made of hemp fibers. (middle) Numerical simulation of a knitted fabric. (right) Ladder defect propagating in a knitted fabric.

The postdoctoral fellows will be part of the larger collaborative team that the Fiscal ANR project brings together. He/she will interact with consortium members and participate in project progress meetings. 3 Post-Doc positions are available:

Mechanics of knitted fabric (Laboratoire de Physique, ENS de Lyon): The postdoctoral fellow will join the group of Audrey Steinberger at ENS de Lyon, on a CNRS contract. The object will be to study experimentally the influence of friction on the global mechanical properties of knitted fabrics, and on the laddering phenomenon which corresponds to the propagation of a topological defect within the fabric as shown in Figure 1 (right). The experiments will be conducted on model fabrics using a biaxial tensile machine and video imaging (standard camera and event camera). Mechanical impedance measurements to evaluate the response to a local excitation can also be developed.

Duration: 15 months, with a possible extension from 2 to 8 months.
Starting date: between 1 November 2024 and 1 March 2025.
Salary: 3021 € to 4208 € per month (before tax), depending on experience.
Application: Send a detailed CV together with a letter of motivation to Audrey Steinberger (audrey.steinberger@ens-lyon.fr) or apply directly through https://emploi.cnrs.fr/Offres/CDD/UMR5672-AUDSTE-001/Default.aspx on CNRS Careers Portal.
Application deadline: 11 november 2024.

Mechanics of twisted yarns and ropes (FAST, Université Paris Saclay): The post-doctoral fellow will join the group of Antoine Seguin (antoine.seguin@univ-saclay.fr) at Université Paris Saclay. The project involves experimental characterization of the mechanical strength of yarns and ropes. A global study of the coupling between torsion and tension in yarns will be carried out through various mechanical tests. These mechanical properties should be linked to the interaction of the fibers (elasticity and friction).

An other part of the project will focus on yielding transition in yarns. The elastoplastic nature of yarns makes them good candidates for the study of these transition. Indeed, when a yarn is pulled, it stretches irreversibly showing a strain hardening effect but does not break instantaneously, with notable irregularities in the stress-strain curve. These force drop events are similar to an avalanche of plastic events that occur above a certain threshold. The objective of this activity is to characterize the statistics of these avalanches and their evolution according to the different elastoplastic properties of the yarn. We want to highlight all this behavior and unveil the analogy of strain hardening with pinning/depinning transition.

Experimental means to carry out these studies will focus on the use of a Traction-Torsion machine (Instron) and the implementation of local strain field measurements by DIC software (LaVision). The academic skills expected of the candidate are in the fields of continuum mechanics and statistical physics, with a keen interest in experimental science.

Duration: 18 months. **Starting date:** between 1 November 2024 and 1 March 2025.
Salary: Between 3081.33€ and 3519.90€ gross per month
Application: Send a detailed CV together with a letter of motivation to Antoine Seguin (antoine.seguin@cnrs.fr) or apply directly through https://emploi.cnrs.fr/Offres/CDD/UMR7608-ANTSEG-001/Default.aspx on CNRS Careers Portal.
Application deadline: 11 november 2024.

Numerical simulations fibers assemblies (University of Rennes): The postdoctoral fellow will join the group of Jérôme Crassous (jerome.crassous@univ-rennes.fr) at University of Rennes. The object will be to use a Discrete Element Model previously developed to investigate the mechanical properties of ropes and knitted fabrics.

It will involve defining complex objects composed of single fibers and subjecting them to virtual mechanical tests. The overall mechanical properties will be related to the deformations of the individual objects and to the contact forces.

The candidate will have a thesis in physics, in a field related to complex systems, disordered media, mechanics or physical hydrodynamics. Knowledge in scientific programming in C is required.

Duration: 18 months. **Starting date:** between 1 November 2024 and 1 March 2025.
Salary: Between 2800€ and 3400€ gross per month
Application: Send a detailed CV together with a letter of motivation to Jérôme Crassous (jerome.crassous@univ-rennes.fr).

References:

- Twist-controlled force amplification and spinning tension transition in yarn
  A Seguin, J Crassous Physical Review Letters 128 (7), 078002 (2022)
- Discrete-element-method model for frictional fibers
  J Crassous Physical Review E 107 (2), 025003 (2023)
- Metastability of a periodic network of threads: what are the shapes of a knitted fabric?
  J Crassous, S Poincloux, A Steinberger arXiv preprint arXiv:2404.07811 (2024)