Physical properties of macroscopic fiber bundles

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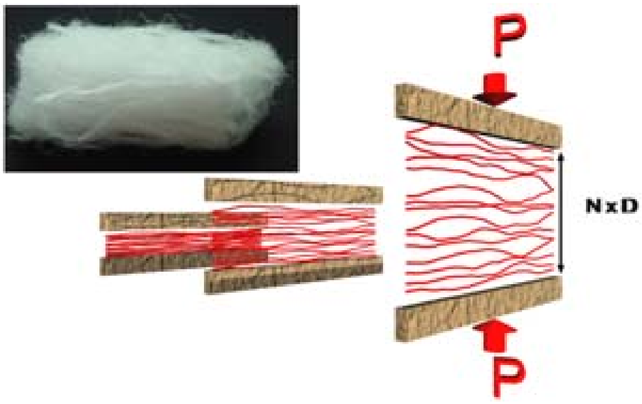

Figure 1: Top: Polypropylen fiber bundles. Right: schematic view of a compression experiments.

In natural and composite bundles of nearly aligned fibers, as for instance in hair tresses and ponytails the waving spontaneous shapes of the strands allow for an intrinsic fluffiness of the materials (see figure insert) [1]. This was first discussed by Van Wyk [2] who suggested that the response of wool stacks to compression is mostly controlled by the bending modes of the fiber strands and proposed an equation of state (EOS) for the material compressibility. More recently, Beckrich *et al.* [3] computed the compression modulus of the fiber stacks within a self-consistent mean-field treatment in two dimensions, and used this EOS to predict the shapes of brooms and other fluffy cones made from fibers. Related arguments were developed by Goldstein *et al.* [4] to explain the cylindrically symmetric 3D shape of hair ponytails and to extract an EOS for the bundle internal compressibility. In an attempt to quantitatively account for fiber geometry we recently develop numerical simulations to study the compression behavior of 2D fiber stacks with intrinsic shape disorder (see figure 1).

The main goal of the PhD project is to investigate both experimentally and numerically the compression law of fiber bundles of various systems. The PhD candidate will build an experimental set-up to make such measurements in a well controlled configuration. Experiments will focus on the mechanical properties of the stack, on the dynamics of force relaxation and on the evolution of the contacts between fibers. During this PhD project, we will also develop image analysis techniques to quantify single fiber disorder. Numerical simulations to understand the compression behaviour of the fiber stacks might also be performed.

[1] B. Audoly, Y. Pomeau, *Elasticity and geometry: from hair curls to the nonlinear response of shells*, Oxford University Press (2010).

[2] C. M. van Wyk, Text. Inst., T285, **37**, (1946).

[3] P. Beckrich, G. Weick, C.M. Marques and T. Charitat, Europhysics Letters, 647-653, **64** (2003).

[4] R. E. Goldstein, P. B. Warren, R. C. Ball, Robin, Physical Review Letters, 078101, **108 (**2012).