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10 AM BOSTON, 3 PM LONDON, 10 PM BEIJING



BASILE AUDOLY
ÉCOLE POLYTECHNIQUE

EITAN GRINSPUN
UNIVERSITY OF TORONTO

PEDRO M. REIS
EPFL

COLLABORATIVE ADVENTURES ON THE GEOMETRICALLY NONLINEAR MECHANICS OF ELASTIC RODS

Thin rods are a class of slender structural elements characterized by a separation of length scales between cross-sectional quantities (e.g., their diameter) and their arc-length. Thin rods theories, à la Kirchhoff, are typically obtained from dimensional reduction of 3D elasticity to a 1D space-curve description along the rod's centerline. Despite the long history of the field, mathematical analysis, modeling, and simulation of elastic rods remain an active field of research in mechanics, numerical analysis, and geometry. Applications of the mechanics of rods are far-reaching, spanning ocean engineering (pipes, cables), nano-engineering (nanotubes, fibers), medicine (catheters), biology (DNA, flagella) and computer graphics (hair, fur). In this talk, we will provide an overview of recent research in elastic rods, using specific examples from our own collaborative research where we have been joining forces to leverage our respective expertise (in theory, computation, and experiments). We address a variety of problems where elasticity and geometric nonlinearities, sometimes coupled with other physical ingredients (e.g., contact, friction, viscous fluids, and surface tension), conspire to offer fundamentally challenging puzzles. Specifically, we will describe recent results from the following problems: mechanics of hair, coiling of elastic rods (or viscous threads) onto a rigid substrate, buckling of a flagellum, and physical knots. Together, these examples illustrate the complementarity of our approaches, with an epicenter in geometry, as well as the power and fun of collaboration across disciplines.

Basile Audoly is a CNRS Senior Researcher at the Laboratoire de Mécanique des Solides (LMS), and Professor at École Polytechnique in France. His research focuses on theoretical mechanics problems, with a particular interest in nonlinear problems involving the coupling of elasticity and geometry. With Yves Pomeau, he has authored the book "Elasticity and Geometry" (Oxford University Press, 2010). **Eitan Grinspun** is a Professor of Computer Science at the University of Toronto in Canada. His research develops computer algorithms for computer graphics applications, with a focus on simulating mechanical systems and processing geometric data. He investigates discrete differential geometry as a tool for constructing these algorithms. **Pedro M. Reis** is a Professor and Director of the Institute of Mechanical Engineering at the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. He focuses on experimental mechanics to study the nonlinear deformation of slender structures, for which he develops reduced physical models guided by precision desktop experiments.¹⁶

Discussion leader: **John Maddocks**, EPFL

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