Building with Fluids, Lazy Design of Functional Materials

Friday, October 12th, 12:30 PM
Maeder Hall

Pierre-Thomas Brun
Assistant Professor
Princeton University

From acoustics to optics, electronics and mechanics, the need for structured materials is well established. Examples include lightweight structural materials, photonics and phononic materials, super-hydrophobic materials and mechanical metamaterials. Despite the recent progress of 3D printing, the fabrication of such structures spanning a wide range of sizes remains difficult or impossible, prompting the development of new fabrication pathways. The work I will present is concerned with the directed control of mechanical instabilities to program shapes. While instabilities are traditionally regarded as a route towards failure in engineering, I aim to follow a different path; taming instabilities and harnessing the patterns and structures they naturally form to fabricate functional materials. This methodology capitalizes on the inherent periodicity, scalability, versatility and robustness of instabilities. This new design paradigm – *building with instabilities* – calls for an improved understanding of instabilities and pattern formation in complex media. While stability analysis is a classic topic in mechanics, little is known on the so called inverse problem: finding the optimal set of initial conditions and interactions that will be transmuted into a target shape without direct external intervention. Three examples will be presented: (1) a fluid-instability based approach for digitally fabricating geometrically complex uniformly sized structures, (2) the rapid fabrication of nearly uniform hemispherical elastic shells by drainage and (3) their pneumatic actuation towards shape morphing applications.

PT Brun received his bachelor's degree in Mechanical Engineering from Ecole Polytechnique, Palaiseau in 2008, his Master's degree in Advanced Chemical Engineering from the University of Cambridge in 2009 and doctorate degree in Mechanical Engineering from Sorbonne University in 2012 for work on the dynamics and instability of viscous and elastic threads. PT then joined the Ecole Polytchnique Federale de Lausanne (EPFL) as a postdoctoral fellow where he specialized on interfacial fluid mechanics and instabilities. In 2014 he joined MIT as an instructor in Applied Mathematics and recently moved to Princeton, where he is a faculty in the department of Chemical and Biological Engineering. His research is curiosity-driven with focus on the quantitative modeling of nonlinear fluid and elastic processes in complex soft materials and the mathematical description of structure formation in inert and biological systems. His work is interdisciplinary and aims to study pattern forming instabilities with view to passively fabricate hierarchical and topological structures in a broad range of materials. His research is conducted hand in hand with the experimental investigations of model experiments. With this perspective, he studies problems involving thin fluid films, viscous threads (3D printing), microfluidics systems, but also elastic shells, swelling and elastocapillarity.

PRINCETON
Mechanical & Aerospace Engineering