# Predicting the mechanical properties of spring networks

Doron Grossman*[1,2] and Arezki Boudaoud[2]

[1]CNRS, IGFL @ ENS-LYON – Centre National de la Recherche Scientifique, École Normale Supérieure - Lyon, Institut de Génomique Fonctionnelle De Lyon (IGFL) – France
[2]Laboratoire d'hydrodynamique – Ecole Polytechnique Université Paris Saclay – France

**Abstract**

The elastic response of mechanical, chemical, and biological systems is often modeled using a discrete arrangement of Hookean springs, either representing finite material elements or even the molecular bonds of a system. However, to date, there is no direct derivation of the relation between a general discrete spring network and it's corresponding elastic continuum. Furthermore, understanding the network's mechanical response requires simulations that may be expensive computationally.
Here we report a method to derive the exact elastic continuum model of any discrete network of springs, requiring network geometry and topology only. We identify and calculate the so-called "non-affine" displacements. Explicit comparison of our calculations to simulations of different crystalline and disordered configurations, shows we successfully capture the mechanics even of auxetic materials. Our method is valid for residually stressed systems with non-trivial geometries, is easily generalizable to other discrete models, and opens the possibility of a rational design of elastic systems.

*Speaker