

The statistical physics of rough contact

Laboratory: Institut de Physique de Nice (INPHYNI)

Internship supervisor: Vincent Bertin, CNRS researcher (vincent.bertin@univ-cotedazur.fr, [website](#))

Possibility of PhD continuation: YES

PhD Funding after internship: not yet secure.

Scientific context

Contact between rough surfaces is ubiquitous, from tactile perception and geological faults to engineered interfaces, and governs friction, adhesion, lubrication and wear. When two rough solids are pressed together, they touch only through a sparse network of microscopic contacts, occupying a small fraction of the apparent contact area. The organization of these microcontacts results from the interplay between surface roughness, spanning many length scales, and long-range elastic interactions that couple distant regions of the interface.

Understanding how this complex microscopic organization determines macroscopic behaviour remains a fundamental challenge. Numerical simulations can now resolve the contact and gap fields in great detail, but such descriptions involve an enormous number of coupled degrees of freedom. In contrast, macroscopic properties such as friction, adhesion or wear may depend on only a small fraction of this microscopic information. This raises a fundamental question: can the complexity of rough contact be reduced to a simple statistical description?

Research objectives

The goal of this internship is to develop an effective statistical description of rough contact. Inspired by the statistical physics of disordered systems and the renormalization group, we will investigate whether the complex organization of microcontacts can be captured by a small number of effective interactions.

Starting from numerical simulations of rough elastic contacts, we will explore a simplified description in which each point of the interface is either in contact or out of contact, drawing inspiration from Ising-like models. We will investigate whether effective interactions can reproduce the spatial correlations and statistical properties of the contact network. Finally, by progressively removing the finest roughness scales, we will study how these interactions evolve with scale, with the ambition of developing a coarse-grained theory of rough contact.

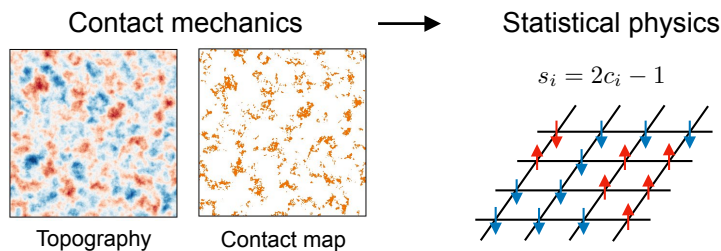


Figure 1: From contact mechanics to statistical physics. Numerical simulations of rough elastic contacts provide microscopic contact maps, which we aim to describe using effective statistical models.

Internship work

During the internship, the student will use the open-source contact mechanics solver Tamaas [1] to simulate elastic contact between randomly rough surfaces and generate ensembles of microscopic contact maps. These simulations will serve as a starting point for exploring two complementary approaches: (i) inferring effective interactions directly from contact statistics using methods from inverse statistical mechanics, or (ii) developing a renormalization-group-inspired approach to describe how effective interactions evolve as roughness scales are progressively eliminated. Depending on the student's interests and background, the internship will focus on one of these two approaches.

Candidate profile: Master student in physics, mechanics or engineering.

Funding for the internship: YES

Date: Starting from February 2027.

To apply: please send a CV and a short email to vincent.bertin@univ-cotedazur.fr

[1] L. Frérot et al., J. Open Source Softw. **5**, 2121 (2020).