Mechanics of contact between rough surfaces

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Abstract

In Hertizan contact macro-solids coming in contact are often assumed to have smooth surfaces. This approach provides an accurate estimation of average strain-stress state, friction, wear, adhesion, leakage, heat and electricity transfer under condition that it is complemented with associated interfacial constitutive models. These models, generally phenomenological, are based on multiple superposed mechanisms occurring at micro-scales of the contacting interface. Due to their excessive complexity arising from the multiphysical and multiscale nature and the lack of scale separation, the underlying microphysical processes resulting in macroscopic properties are often not clear. Trying to access more fundamental properties and lower scale constitutive laws, one needs to introduce in the model the elementary micro-scale properties (e.g., roughness, surface energy, underlying microstructure, chemical properties) and mechanisms (e.g., adhesion, mechanical deformations adapted to the contact scale, heat transfer, tunnel effect, Cazimir effect).

Roughness is one of the important properties of surfaces encountered in nature and engineering. Its presence has important implications on the mechanics and physics of contact: (i) local contact stresses fluctuate strongly from the mean contact pressure, (ii) true contact area in most cases presents only a small fraction of the nominal contact area. These consequences are relevant for strength analysis, wear, friction, adhesion, percolation and energy transfer through the contact interface.

In the first part (I) we carry out numerical simulations of contact between rough elastic half-spaces using the Boundary Element Method. We analyze the influence of surface normality, cutoff wavelengths and spectrum breadth (Nayaks parameter) on the evolution of the contact area, contact perimeter and the probability density of contact pressure. The results are compared with analytical and numerical models.

In the second part (II) we analyze a contact between elasto-plastic solids with incorporated roughness taken from experimental measurements. Two types of models are considered: a full finite-element model and a simple asperity based model. This model reposes on numerous tests performed on single elasto-plastic asperities and on the deformation of elasto-plastic media, which ensures the interaction between asperities. Consequently a fluid transfer through the contact interface is analyzed by means of thermal analogy.

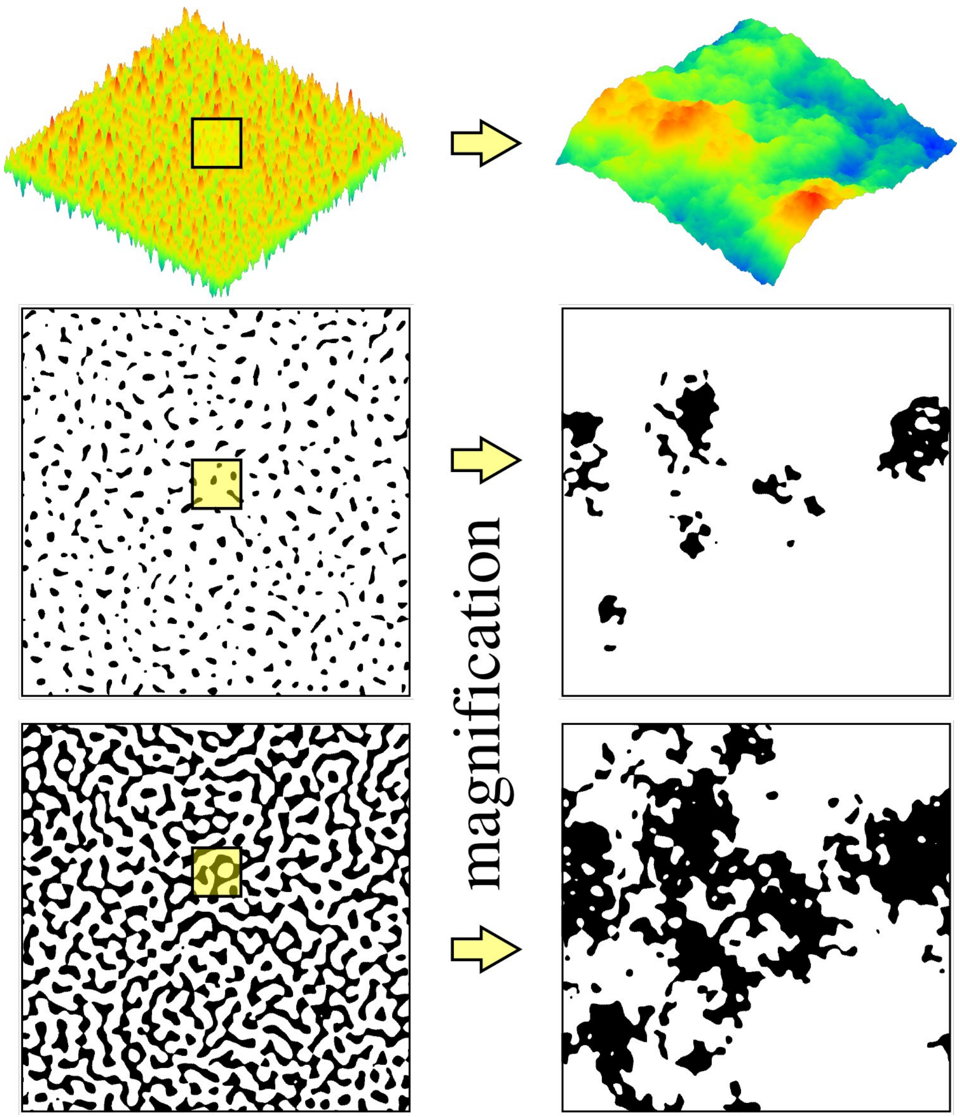

Figure 1: Rough surfaces (first line) under different magnification and corresponding contact areas at different pressures.