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Elastic contact between representative rough surfaces

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Introduction

Under a certain magnification all surfaces are rough. This roughness determines the mechanics of the contact, onset of plasticity, wear, friction and the properties of heat and electricity transfer. An important parameter characterizing the mechanics and physics of the rough contact is the real contact area. We study the evolution of the real contact area under the increasing contact pressure. We compare our results to the existing theoretical models [Bush et al., 1975*; Persson, 2001*] and deduce a quite general contact evolution law. For that purpose we use a mechanically complete numerical model for elastic contact.

Methods

A realistic roughness is self-affine and the surface heights follow a normal distribution. We use a filtering algorithm in Fourier space [*Hu and Tonde, 1992*] to generate rough surfaces. To make the study statistically meaningful, 30 surfaces are generated for a given Hurst roughness exponent and two cut-off frequencies in the surface spectra. The highest frequency determines the smallest asperities, which should be well resolved in the mechanical sense for a given discretization of the computational mesh. The lowest frequency in the surface spectrum determines the representativity of the surface, which is responsible for the proximity of the surface's heights distribution to a normal one.

To solve the mechanical contact problem (Fig. 1), we use an FFT based boundary element method [*Stanley and Kato, 1997*] which allows us to compute accurately the contact pressure and the contact area between two semi-infinite elastic solids with periodic roughness.

Results and discussions

We show that the lowest frequency in the surface spectrum has to be big enough, i.e. the surface should be representative, to obtain the results corresponding to realistic roughness. We demonstrate also that for considered surfaces the evolution of the real contact area is significantly more linear than predicted by asperity based theoretical models. The slope of this evolution for infinitesimal contact is very close to the constant found by [*Bush et al., 1975*] and is significantly higher than the value predicted by [*Persson, 2001*]. We suggest a phenomenological contact evolution law valid up to about 40 percent of the relative contact area [*Yastrebov et al., 2012*].

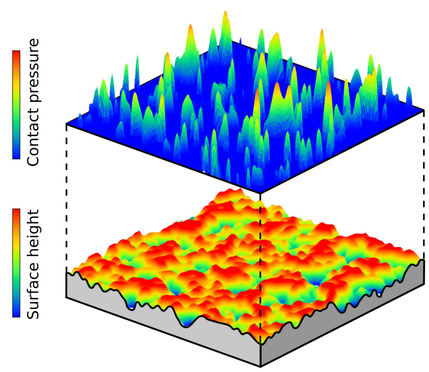

Fig. 1. Contact between rough surfaces: bottom – scaled superposition of roughness; top – contact pressure.

References

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