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Torque-controlled micro-slip front propagation along elastomer multicontacts

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The onset of sliding of planar rough contacts is mediated by the propagation of micro-slip fronts along the interface. The local criteria that control the location of the front nucleation location, and the propagation speed and direction have been largely investigated, and partially elucidated. However, the practical means to setup an interface in order to control the properties of a future micro-slip front remain mainly unexplored. Here, we propose a loading procedure enabling control of the nucleation location, propagation direction and propagation speed, as demonstrated through experimental results based on in-situ monitoring of the fields of contact area and shear displacements. Those measurements are rationalized using, and quantitatively compared with, a simple quasistatic model, allowing model validation and enhancement.

Keywords: onset of sliding, PDMS, digital image correlation, friction-induced torque

1. Introduction

The properties of the micro-slip fronts that nucleate and propagate along rough contact interfaces at the transition between static and dynamic friction have been widely investigated in the last 15 years [1,2]. In particular, the relationship between (i) the local normal and shear stresses at the interface and (ii) the location of the nucleation point and front propagation speed have been mainly elucidated. However, those stresses depend in an intricate way on the geometry of the contacting bodies and on the exact way the external loads are applied to the solids. As a consequence, there is currently no established way to setup a contact interface such that the nucleation location, propagation direction and speed are controlled a priori. Here we describe how, through the application of a controlled torque at the interface when it is progressively sheared towards sliding, we can pilot those micro-slip front features. Through quantitative comparison with a quasistatic model, we will provide a clear explanation for such a capability.

2. Methods

Experimentally, we performed various shear loading experiments on planar contact interfaces similar to those investigated in [3,4], between randomly rough elastomer samples and smooth glass plates. The normal load, N, and loading speed are kept constant throughout the experiments. The originality is that the torque induced by the increase of tangential force, F, on the contact can be adjusted through the height of application, H, of this tangential force with respect to the contact plane (Fig.1). During those experiments, the fields of real contact area (through image segmentation), and of tangential displacement (through image correlation) are monitored optically.
The model used is based on the torque model of Ref. [5], but adapted to take into account the following additional physical ingredient: the shear-induced decrease of the real contact area [3] and the shear stiffness of the multicontact interface.

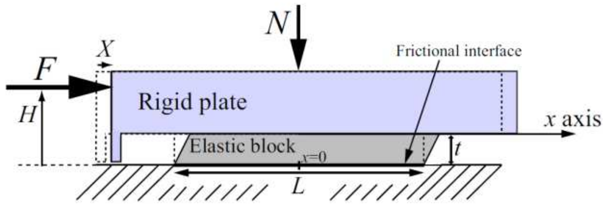

Fig. 1: Sketch of the experimental setup, including the variables of the model of Ref. [5].

3. Discussion

By changing the sign of the friction-induced torque, we managed to nucleate slip at either sides of the contact interface, and thus to pilot the propagation direction. The amplitude of the torque, in turn, controls the propagation speed, which is shown to be quasistatic in most of the explored cases. Quantitative comparison between measurements and model predictions is achieved. The shear stiffness of the multicontact interface is extracted and shown to be in good agreement with the predictions derived in Ref. [6].

4. References

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