

Precursors to sliding and static friction threshold of heterogeneous frictional interfaces

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Résumé :

Nous utilisons un modèle multi-échelles de la transition entre frottement statique et frottement dynamique, pour étudier la vitesse des fronts de rupture le long d'interfaces multi-contact étendues. Nous montrons que la vitesse des fronts est directement contrôlée par la vitesse de glissement associée, pour toute la gamme de vitesses explorée. Nous proposons ensuite un classement, basé sur les mécanismes en jeu, pour les différents types de fronts observés. Nous montrons finalement comment le coefficient de frottement statique local est contrôlé par l'histoire du glissement, au même endroit, mais lors de la rupture précédente de l'interface.

Abstract :

We use a multi-scale model for the transition from static to dynamic friction to investigate the speed of rupture fronts along extended multi-contact interfaces. We show that front speed is directly controlled by slip speed across the full speed range explored. We then propose a mechanism-based classification of the various front types. We finally show how the local static friction coefficient is controlled by the slip history of the previous rupture of the interface.

Mots clefs : Multicontact interfaces, onset of sliding, rupture front, front speed, static friction, multi-scale model

1 Introduction

The transition from stick to slip at a dry frictional interface occurs through the breaking of the junctions between the two contacting surfaces. Typically, interactions between the junctions through the bulk lead to rupture fronts propagating from weak and/or highly stressed regions, whose junctions break first. Experiments find rupture fronts ranging from quasi-static fronts with speeds proportional to external loading rates [1], via fronts much slower than the Rayleigh wave speed [2], and fronts that

propagate near the Rayleigh wave speed, to fronts that travel faster than the shear wave speed [3]. The mechanisms behind and selection between these fronts are still imperfectly understood.

2 Methods

Here we perform simulations in an elastic 2D spring-block model where the frictional interaction between each interfacial block and the substrate arises from a set of junctions modeled explicitly [4]. The full model is identical to the one first described in [5].

3 Results

We find that a proportionality between material slip speed and rupture front speed, previously reported for slow fronts [5], actually holds across the full range of front speeds we observe. We revisit a mechanism for slow slip in the model and demonstrate that fast slip and fast fronts have a different, inertial origin. We highlight the long transients in front speed even in homogeneous interfaces, and we study how both the local shear to normal stress ratio and the local strength are involved in the selection of front type and front speed. Lastly, we introduce an experimentally accessible integrated measure of block slip history, the Gini coefficient, and demonstrate that in the model it is a good predictor of the history-dependent local static friction coefficient of the interface. These results [6] will contribute both to building a physically-based classification of the various types of fronts and to identifying the important mechanisms involved in the selection of their propagation speed.

Références

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