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PREDICTING THE LENGTH OF SLIP PRECURSORS

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The transition of sticking to sliding of a frictional interface was shown to present a variety of different mechanisms in laboratory experiments [1]. One particular observation was the appearance of so-called precursors to global sliding [1, 2]. In these experiments, a thin PMMA block (slider) was brought in contact with a thicker base of the same material. First, a constant normal load is applied to the top face of the slider. After equilibrium is achieved, a shear load, which is slowly increased over time, is applied via a pusher to the slider's side. By monitoring the global forces as well as the interface slip, it was observed that local slip events propagate along the interface well before global sliding occurs. These precursors always start at the trailing edge, where the pusher is applied, and each slip event propagates farther than the previous one, but stop before they reach the other edge. Macroscopic sliding was eventually observed when a rupture propagates over the entire interface.

The lengths of these precursors and, in particular, the relation between the precursor lengths and the ratio of the macroscopic shear to normal force present an interesting behavior (see Fig. 1a). The lengths increase approximately linearly until the center of the interface where they start to increase much more. Then, only very few slip events are necessary to reach the other edge resulting in global sliding. This observation has been analyzed numerically using mainly mass-spring models [3]. While these studies were able to reproduce qualitatively this non-linear effect between precursor lengths and macroscopic force ratio, its origin is still not well understood.

We present the results of two additional approaches to model precursors at frictional interfaces (see Fig. 1b). First we use a state-of-the-art finite-element model [4] to show that fully dynamic and continuum simulations present the same precursor propagation

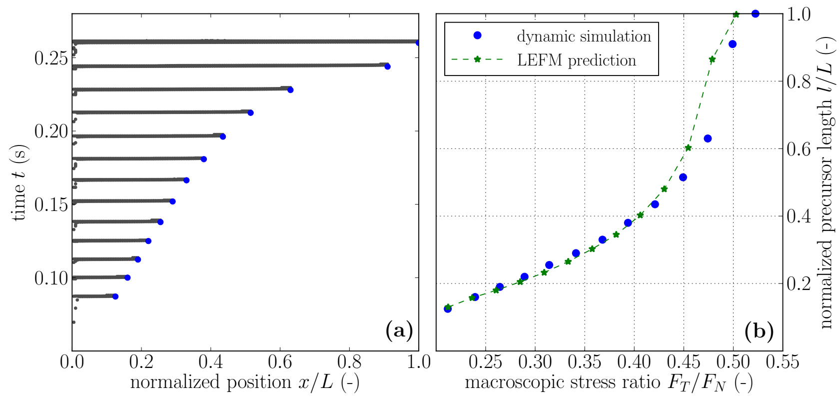

Figure 1: (a) The propagation length of precursors is shown with gray areas indicating slip. Blue dots mark the precursor arrest position. (b) The normalized precursor length is presented with respect to the macroscopic stress ratio for a fully dynamic simulation and the theoretical model.

pattern. This model enables us to obtain high-resolution access to the stress state of the interface. Using this information, we reveal that the bulk viscosity influences the stress state of the interface, which is one among other reasons for stress heterogeneities at the interface [5]. These insights are then applied in a theoretical model based on Linear Elastic Fracture Mechanics, which is the second approach we present. We first show that this theoretical model also reproduces the relation between the precursor length and the macroscopic force ratio. We then analyze the influence of different parameters and find a weak effect of bulk properties and the number of precursors but a stronger effect of the interface properties and state.

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