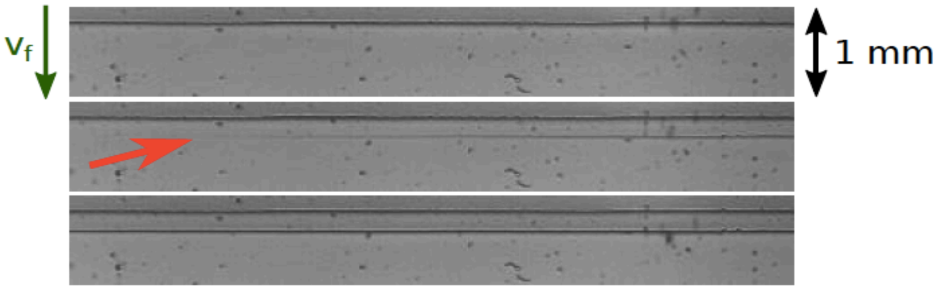
Inertial effects on the multi-scale stick-slip dynamics in adhesive tape peeling

Everyone has experienced the unpleasant screechy sound when peeling-off packing tape. This noise is the signature of a dynamical stick-slip instability, with periodic velocity oscillations of the peel front. Despite a large number of studies, such instability still causes industrial problems, bringing forward challenging questions. Recent studies have demonstrated that the unstable front dynamics is even a more complex process, involving a secondary instability at much smaller spatio-temporal scales than the macroscopic stick-slip.

Thanks to an extensive experimental study, we have been able to unveil the precise characteristics of this peel front micro-instability. In particular, the amplitude of this instability scales with its period as $A \sim T^{1/3}$, with a pre-factor evolving slightly with the peel angle, and increasing systematically with the bending modulus of the tape backing. A local energy balance of the detachment process shows that the elastic bending energy stored in the tape region that will detach during the micro-slip is converted into a kinetic energy increase of the peeled tape during a micro-stick-slip cycle.

Our model allows a quantitative description of the observed scaling-law linking amplitudes and periods of the micro-instability, and in particular its dependency with the peeling angle, as well as with the bending modulus and lineic mass of the ribbon.



Legend: Chrono-photography of the detachment front (time interval between each image is 20 µs) during a typical peel experiment (peel velocity 1 m/s, peel angle 90°, and peeled length 50 cm). The red arrow indicates the tip of the fracture kink, which propagates in the transverse direction across the tape width.

References:

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