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Nucleation of frictional sliding

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The onset of frictional motion is mediated by the propagation of rupture fronts, which nucleate quasi-statically in a localized region and slowly increase in size. When a rupture reaches a critical nucleation length it becomes unstable, propagates dynamically and eventually breaks the entire interface, leading to macroscopic sliding. The nucleation process is particularly important because it determines the stress level at which the frictional interface fails, and therefore, the macroscopic friction strength. However, the mechanisms governing nucleation of frictional rupture fronts are still not well understood. Here, we use a combination of numerical simulations and theoretical models to study the nucleation of local slip at interfaces with slip-weakening friction of random strength and analyze the resulting variability in the measured global strength and the nucleation pattern. Our results show that the growth of the critical nucleation patch at interfaces with small correlation lengths is non smooth due to the coalescence of neighboring slip patches. Conversely, when the correlation length is large, the growth of the slip patch is continuous. Increasing spatial correlation length leads to lower macroscopic friction strength [1]. Finally, we identify three distinct nucleation regimes [2]: (i) a subcritical regime where the correlation length is small and the interface strength corresponds to the average strength (homogenization limit), (ii) a critical regime where the correlation length is similar to the nucleation length and coalescence dominates the growth, and (iii) a homogeneous regime where the correlation length is large, the growth is continuous, and the strength corresponds to the global minimum.

[1] G. Albertini, S Karrer, M.D. Grigoriu, D.S. Kammer, J. Mech. Phys. Solids, 147, 104242 (2021)
[2] S. Schär, G. Albertini, D.S. Kammer, Int. J. Solids Structures, 220, 111059 (2021)