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Friction Networks: Network-Configurations of Dynamic Friction Patterns

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The complex configurations of dynamic friction patterns–regarding real time contact areas– are transformed into appropriate networks. With this transformation of a system to network space, many properties can be inferred about the structure and dynamics of the system. Here, we analyze the dynamics of static friction, i.e. nucleation processes, with respect to "friction networks". We show that networks can successfully capture the crack-like shear ruptures and possible corresponding acoustic features. We found that the fraction of triangles remarkably scales with the detachment fronts. There is a universal power law between nodes' degree and motifs frequency . We confirmed the obtained universality in aperture-based friction networks. Based on the achieved results, we extracted a possible friction law in terms of network parameters and compared it with the rate and state friction laws. In particular, the evolutions of loops are scaled with power law, indicating the aggregation of cycles around hub nodes. Also, the transition to slow rupture is scaled with the fast variation of local heterogeneity. Furthermore, the motif distributions and modularity space of networks –in terms of within-module degree and participation coefficient–show non-uniform general trends, indicating a universal aspect of energy flow in shear ruptures.
As a conclusion to our study, we introduced friction networks over dynamics of different real time contact areas. Based on our solid observations, we formulated a probabilistic frame for the evolution of the state variable in terms of friction networks. Moreover, we confirmed that slow ruptures generally hold small localization, while regular ruptures carry a high level of energy localization. We also introduced two new universalities with respect to the evolution of dry frictional interfaces: the scaling of local and global characteristics and the occupation of certain regions of modularity parameter space. Our results showed how the relatively highly correlated "elements" of an interface can reveal more features of the underlying dynamics. We proposed that assortativity as an index to correlation of node's degree can completely uncover acoustic features of the interfaces. Our formulation can be coupled with elasto-dynamic equations to complete our understanding of the interface's more realistic features.

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