Scaling relations in sliding friction of polymer gels

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Laboratory experiments have been conducted for years to understand underlying mechanisms of rupture dynamics along faults. Most of such studies are aimed at model experiments for elementary processes or measurement of the constitutive law, while very few are designed to study the rupture dynamics in a wide area, where spatio-temporal complexity and the interactions between the faults are important.

In this presentation, we report our experimental studies on spatio-temporally heterogeneous stick-slip motions in the sliding friction of a poly-methyl methacrylate (plexiglass) block sliding on a soft poly-dimethyl siloxane (PDMS) gel plate. The probability distributions for the drop in frictional force obeys a power law, similar to Gutenberg-Richter's law for earthquakes, and the exponent of the power law decreases with increasing plate velocity. Bimodal distributions are observed for the force where an slip event occur, suggesting that there are two types regimes, i.e., small event regime and quiet regime prior to large events regime during loading period. We propose a simple model to explain the plate velocity dependence on the power law exponent, which agrees well with experimental results. Furthermore, the relationship between the event size and its duration is also shown. We find that the scaling relation $T \sim \delta F^{\alpha}$ with the exponent α satisfies $1, 1/3$ as well as $1/2$. We discuss how these characteristic exponents are determined from observations of the slip as well as the rupture dimensions in our experiments.