RUPTURE DYNAMICS ON FAULTS WITH CONTINUING SLIP WEAKENING: DOES THE TAIL WAG THE DOG?

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Continuing fault weakening with co-seismic slip has been inferred from seismological observations of earthquakes [Abercrombie and Rice 2005] and laboratory quakes [Paglialunga et al 2022]. Thermal pressurization (TP) of pore fluids by shear heating has shown to be a possibly ubiquitous mechanism leading to continuing fault weakening in agreement with the observations [Viesca and Garagash 2015].

Continuing co-seismic weakening implies that the breakdown of fault strength is not localized near the rupture front, contrary to classical earthquake source mechanics models, while the associated energy dissipation (breakdown work) is accrued over the entire slipping fault. A related fundamental question is to what extent the rupture-wide energy dissipation governs the dynamics of the rupture front propagation.

We address this question by numerical simulations of ruptures driven by continuous weakening, and analytical modeling using an approximately equivalent Linear Elastic Fracture Mechanics (LEFM) framework. We use a proxy slip-weakening law $\tau \propto \delta^{-1/3}$ [Herrera et al 2024] to mimic the actual weakening observed in steady TP-driven dynamic rupture solutions [Viesca and Garagash 2015].

Preliminary results of matching the numerical simulations to the predictions of the LEFM model show that at moderate rupture speeds the fault-wide breakdown work W_b is approximately equal to the LEFM fracture energy governing the rupture front dynamics. At larger speeds, approaching shear-wave speed, the equivalent LEFM fracture energy is a speed-dependent fraction of W_b. Our results suggest that the energy dissipation away from the rupture front does shape the front dynamics, i.e. 'tail wags dog', but the effect is modulated by the rupture speed.