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# Dynamic fracture in laboratory earthquakes

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Several challenging issues about the character of dynamic earthquake rupture have been recently raised. In particular they concern the acceptable ranges of stable rupture propagation velocity and the possibility that slip occurs in short, self-healing pulses. While the above issues are closely related to the frictional behavior, it is difficult to predict the effects of surface roughness and friction complexity and to include them in simulations with classical numerical tools. In alternative, we illustrate here a series of novel observations obtained in laboratory experiments with a photographic method. Two precut samples were put in contact on their edge, under uniaxial load of 1-13 kN, at an angle close to instability in order to ensure the spontaneous triggering of fracture. The samples consist of 8 mm thickness plates of CR (Columbia Resin, a hard synthetic material with compressional waves $V_p \approx 1800$m/s). A high speed digital camera with inter-frame intervals of $10\mu$sec acquired image sequences of fracture propagation. The entire process is observed, starting from slow fracture initiation, to acceleration and fully dynamic propagation at sonic and supershear velocity. In order to explore a variety of friction conditions, experiments were performed either: (a) after surface roughening and insertion of lubricating material at isolated points along the contact. (b) In plain contact between the precut smoothed edges. Experiments of type (a) show an elevated degree of complexity, including re-rupturing episodes on the same surface within short time intervals, suggesting rapid re-strengthening of the surface and the formation of self-healing pulses. The more repeatable experiments of type (b) reveal a consistent set of 3 propagation velocities $V_r$: (1) subsonic dynamic propagation ($V_r$ close to the Rayleigh wave velocity), (2) supershear rupture propagation ($V_s < V_r < V_p$) and (3) an extremely slow, but stable propagation velocity ($40 < V_r < 60$m/s), essentially observed after the beginning of instability but before

acceleration toward the dynamic propagation.