THE DYNAMICS OF ELONGATED EARTHQUAKE RUPTURES

Huihui WENG, ***Jean-Paul AMPUERO***

Université Côte d'Azur, IRD, CNRS, Observatoire de la Côte d'Azur, Géoazur, Sophia Antipolis, Valbonne, France

Both large and small earthquakes develop elongated ruptures with large length-to-width ratios. The energetics of such elongated pulse-like ruptures is radically different from that of conventional circular crack models, but a synoptic understanding of their dynamics is still missing. Here we combine computational and analytical modeling of long ruptures in 3D (mode II and III) to develop a theoretical relation between the evolution of rupture speed and the spatial distribution of fault stress, fracture energy and rupture width. The evolution of elongated sub-shear ruptures is well described by the theoretical rupture-tip-equation-of-motion, which has an inertial feature and depends explicitly on rupture acceleration. The steady energy release rate is limited by rupture width rather than rupture length. For super-shear ruptures, it also depends on rupture speed. The analytic result predicts steady-state supershear ruptures, which are also validated numerically. This inertial effect does not exist in the classical theory of dynamic rupture in 2D unbounded media, but emerges in bounded media or, as shown here, as a consequence of the finite rupture width. Based on the theoretical equation we define the rupture potential, a function that determines the size of earthquake, and we propose a conceptual model that helps rationalize one type of "super-cycles" observed on segmented faults. More generally, the theory developed here can yield relations between earthquake source properties and the heterogeneities of stress and strength along the fault, which can then be used to extract statistical information on fault heterogeneity from source time functions of past earthquakes or as physics-based constraints on finite-fault source inversion and on seismic hazard assessment.