Elastic Impact Consequences for High-Frequency Earthquake Ground Motions

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A fundamental question of earthquake science is what produces damaging high-frequency ground motion, with the classic Brune-Haskell model postulating that abrupt initiation of fault slip causes it. However, even when amended with heterogeneous rupture, frictional slip models fail to explain observations of different sized repeating earthquakes, and have challenges explaining high-frequency radiation patterns as well as the dependence of stress drops on fault maturity and depth. We propose an additional cause for high-frequency earthquake spectra from elastic collisions of structures within a rupturing fault zone. The collision spectrum is set by an impact contact time that is proportional to the size of colliding structures, so that spectra depend on fundamentally different physical parameters compared with slip models. When added to standard frictional models, the collision model can reconcile the discrepant observations, since the size, shape and orientation of structures vary between different fault zones but remain constant within a given fault segment. High-frequency earthquake ground motions and damage may therefore be an outgrowth of fault-zone structure rather than sudden initiation of slip.