# Numerical modeling of physical processes occurring during the spontaneous propagation of 3-D earthquake ruptures

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Some solutions of the fundamental elasto-dynamic equation obtained by using a Finite Difference numerical code are presented. We model the fully dynamic spontaneous propagation of truly 3-D earthquake ruptures on planar faults embedded in an elastic half-space. We implement the Traction-at-Split-Nodes fault boundary condition using different governing laws. To prescribe the traction evolution within the breakdown zone we can adopt either slip-dependent laws or rate- and state-dependent friction laws, which involve the choice of an evolution relation for the state variable(s). Our numerical procedure allows the use of oblique and heterogeneous distribution of initial stress and allows the rake rotation during rupture propagation. This implies that the two components of fault slip velocity and total dynamic traction are coupled together to satisfy the adopted constitutive law. It is possible to chose various strategy to force the rupture nucleation and absorbing boundary conditions are implemented in order to reduce the computational requests and time.

Among the various competing physical mechanisms occurring during faulting a special emphasis is given to the temporal variations of the effective normal stress, caused by thermal pressurization of pore fluids, for which an analytical solution is given. We also consider the evolution of the porosity, which is able to change the value of the so-called fracture energy.

Finally, we study the effects of super-shear rupture speed on the high frequency content of S-waves. We demonstrate that crack tips governed by different friction laws propagating at super–shear speed have slip velocity functions with reduced high frequency content compared to crack tips travelling at sub–shear speeds. Additionally, we show that the Mach cone amplification of high frequencies overwhelms the deamplification of high frequency content in the slip velocity functions in super–shear ruptures.