Different Fault Implementation for Earthquake Dynamic-Rupture modeling.

N. Moussatat, Emmanuel Chaljub, L. Baillet

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N. Moussatat[1], E. Chaljub[2], L. Baillet[3]

[1] *ISTerre, CNRS, Grenoble University, France, moussatn,emmanuel@obs.ujf-grenoble.fr*
[2] *ISTerre, CNRS, Grenoble University, France, emmanuel.chaljub@obs.ujf-grenoble.fr*
[3] *ISTerre, CNRS, Grenoble University, France, laurent.baillet@obs.ujf-grenoble.fr*

Résumé — We present large scale Dynamic Rupture simulations for a normal fault in SuperShear Mode inside various half-spaces. Our simulation are done with Lagrange Multiplier method on non-matching grids in Large Deformation and we compare the rupture front on the fault as well as the free-surface wave fields with the one obtained by other contact algorithm implementations.
Mots clés — Dynamic Rupture, Large Deformation, Lagrange Multiplier.

1 Introduction

Fault Friction Parameters, fault geometry and pre-stresses are key in understanding the behavior of a dynamic rupture initiation and propagation. Recent Laboratory optical experiments by Rosakis exhibited rupture propagations SubShear and SuperShear modes, and studied fault behavior in the cohesive zone just behind the rupture front. Various numerical implementation are used to model experiments as well as large scale crustal dynamics. The Southern California Earthquake Center (SCEC) and the U.S. Geological Survey (USGS) started *The Spontaneous Rupture Code Verification Project* ([5]) by setting benchmarks for large scale earthquake dynamic rupture simulations, enabling comparative study between numerical simulations done by various different codes.

While various numerical bodies simulations are used in the SCEC Verification Project, most modelers used a trial contact algorithm called "Traction-at-Split-Node" ([4]) for the fault behavior. TSN rely on a node-to-node enforcement of the contact constraint while prohibiting any fault opening thus restricting simulations to an infinitesimal strain formulation with a discretization along on-fault matching-grids.

With PLAST2D, we implemented a variational formulation of rupture propagation in Large Deformation with Lagrange Multiplier method on non-matching grids. Discretization is done by a Node-To-Segment Linear Elements with smooth spline contact, as well as Linear Mortar Elements. For efficiency, we used Explicit Scheme for the Dynamical Contact ([3]).

We applied our model to the TPV11 setup : spontaneous rupture propagation along a 60° dip-slip normal-fault in homogeneous half-space, with linearly depth-dependent Pre-Stresses and the where the friction model is a Linear Slip Weakening corresponding to a Super-Shear Rupture Mode (Figure 1). We extend our simulation to a non-homogeneous half-space and confront our results with those obtained with Cohesive Cells on a matching grid as implemented by Pylith (developed by the CIG, [1], [2]).

We present convergence results with decreasing grid sizes. Similar velocities results are obtained for nodes placed 1km off-fault while disparities for the slip-rate along the fault are exhibited between different contact-algorithm implementations and grid coarseness.

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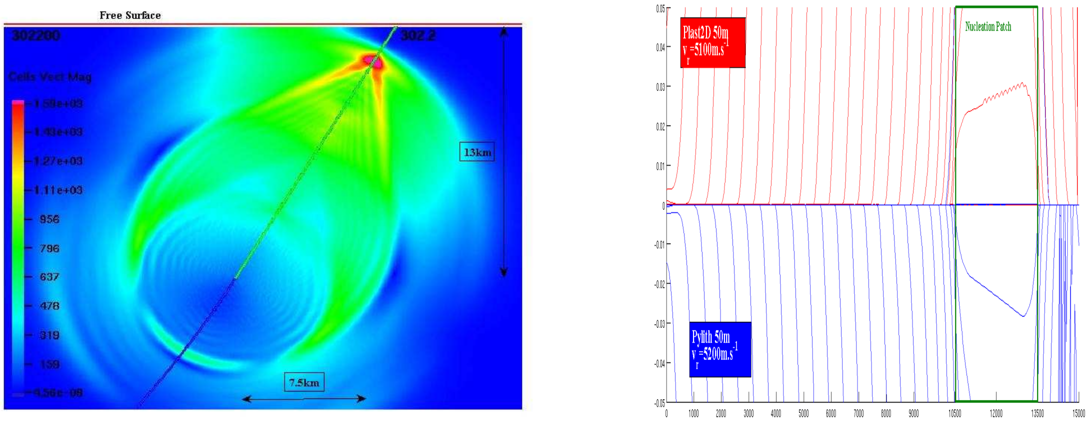

FIGURE 1 – SCEC's TPV11 : (*Left*) Nucleation is initiated around a patch centered at 12km down-dip followed by spontaneous SuperShear rupture on a 60 degree dipping dip-slip fault (normal fault) in a homogeneous half-space. Initial stress conditions are linearly dependent on depth. Snapshot of the Velocity at $t = 2.2s$. Slip is allowed on the first 15km long of the fault. The blue dots on fault are nodes where Slip is not allowed. (*Right*)Total Slip in meters plotted every 0.1s, along node Position on Fault for a N-T-S (Plast2D) algorithm and a Cohesive Cell (Pylith) type in Lagrange Multiplier. Grid size is 50m on the fault.

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