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Coupling solid and fluid dynamics within rapidly growing fractures

Fabian Barras[1,*], Gaute Linga[1], Eirik Grude Flekkøy[1] and François Renard[1]

[1] The Njord Centre, Dept. of Physics, Dept. of Geosciences, University of Oslo, Norway
[*] Presenting author; fabian.barras@mn.uio.no

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At the front of a propagating earthquake, large stress and pressure gradients arise from the rapid change in porosity created by the dynamic rupture along the fault and in the surrounding rock. Under water-saturated conditions, this rapid expansion of fluid-filled cavities and fractures could lead to transient phenomena (e.g. vaporization [5]) impacting the propagating seismic rupture. Recent years have seen significant advance in the development of hydraulic fracture models, for which tensile fracturing is driven by the build-up of fluid pressure within the crack cavity through a slow and stable process [3]. In parallel, models simulating the effect of dynamic waves on static fluid-saturated cavities have been developed in the context of seismic tomography [4].

In this work, we propose a numerical model that fully couples solid and fluid flow dynamics at the tip of a rapidly growing tensile fracture. The geometry consists of a single in-plane fluid-filled crack propagating at the interface between two impermeable semi-infinite solids. The dynamic fracture description rests upon a boundary integral formulation of the elastodynamic equations [1, 2], whereas fluid flow is simulated using a width-averaged formulation of the compressible Navier-Stokes equations integrated on a moving crack. We validate the approach by comparison to analytical expressions existing in certain limits and discuss its capability to explore transient dynamics at the fracture tip.

REFERENCES

[1] Roch, T., Barras, F. and Geubelle, P.H. and Molinari, J.-F. cRacklet: a spectral boundary integral method library for interfacial rupture simulation. *Journal of Open Source Software*, (2022) **69**:3724

[2] Breitenfeld, M.S. and Geubelle, P.H. Numerical analysis of dynamic debonding under 2D in-plane and 3D loading. *International Journal of Fracture*, (1998) **93**:13–38

[3] Lecampion, B. and Bunger, A. and Zhang, X. Numerical methods for hydraulic fracture propagation: A review of recent trends. *Journal of Natural Gas Science and Engineering*, (2018) **49**:66–83

[4] O'Reilly, O. and Dunham, E.M. and Nordström, J. Simulation of wave propagation along fluid-filled cracks using high-order summation-by-parts operators and implicit-explicit time stepping. *SIAM Journal on Scientific Computing*, (2017) **39**:B675–B702

[5] Brantut, N. Dilatancy-induced fluid pressure drop during dynamic rupture: Direct experimental evidence and consequences for earthquake dynamics. *Earth and Planetary Science Letters*, (2020) **538**:116179