ETH zürich

Julia computing

ETH – Master Thesis project 2023

Development of a 3-D JULIA software package for modeling earthquake physics

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Scope and motivation

There is a growing interest in understanding how geologic faults respond to transient source of fluids. This issue has become a societal concern due to the increasing interest in geothermal energy, CO_2 storage, or injection of fluids associated with hydraulic fracking (Fig. 1). To this end, computational earth science often relies on modelling to understand complex physical systems which cannot be directly observed. An important domain where this is true is earthquake physics, concerned with elastodynamic shear rupture during earthquakes, (in)elastic deformation, inertial wave-mediated effects, and solid fluid interaction.

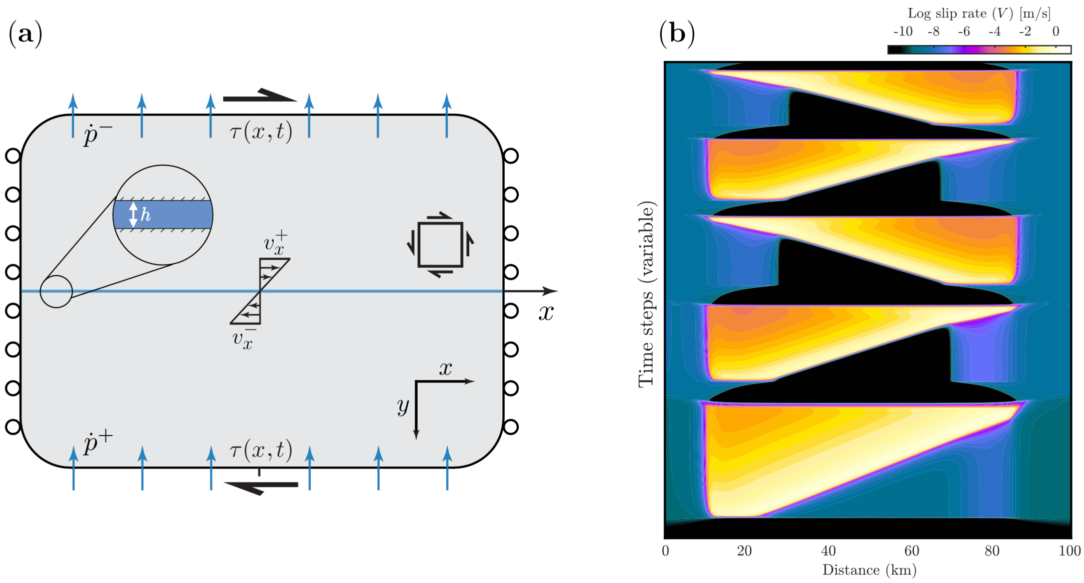

Figure 1: (**a**) llustration of the model setup. In-plane shear zone embedded in a homogeneous poro-visco-elasto-plastic media, with the shear layer undergoing uniform strain and a relative displacement. (**b**) Overview of the results showing the temporal evolution of maximum slip velocity.

In this master thesis project, we seek a motivated student to develop a new open-source JULIA software package to model earthquake physics, which will provide a way forward by exploiting two powerful emerging paradigms in High-Performance Computing (HPC): massively parallel relaxation-based solvers, and HPC with JULIA. Solvers based on pseudo-transient relaxation on Finite Difference staggered grids show great promise for solving a wide range of mechanical multi-physics problems in geoscience, at scale and on GPU-accelerated clusters. Our proposed tools encapsulate these proven techniques and make them available in a reusable, extensible, and high-performance framework, so that they may be applied within existing application codes and used to develop new ones. Supported physics will include: inertial wave-mediated effects, 2-phase (Darcy) flow and coupled Stokes, and rate-and-state dependent friction.

Goals

This thesis aims to target the following tasks:

- Development of a 2-/3-D unified and generalized model for 2-phase porous media in JULIA , harnessing the high-performance computing facilities of the EULER cluster at ETH Zurich
- Implement inertial wave-mediated effects
- Test an explicit pseudo-transient time stepping

We expect a highly-motivated student to be interested in geophysics, and rock rheology, have some experience in Numerical Modeling (e.g., finite difference method) and in programming software (e.g., MatLab, experience in Julia is not needed), and be motivated to work in an international and interdisciplinary team.

Questions can be directed to Dr. Luca Dal Zilio (*luca.dalzilio@erdw.ethz.ch*) and Dr. Albert De Montserrat Navarro (*albertde-montserratnavarro@erdw.ethz.ch*).