Undergraduate research openings

Waves & Imaging Laboratory
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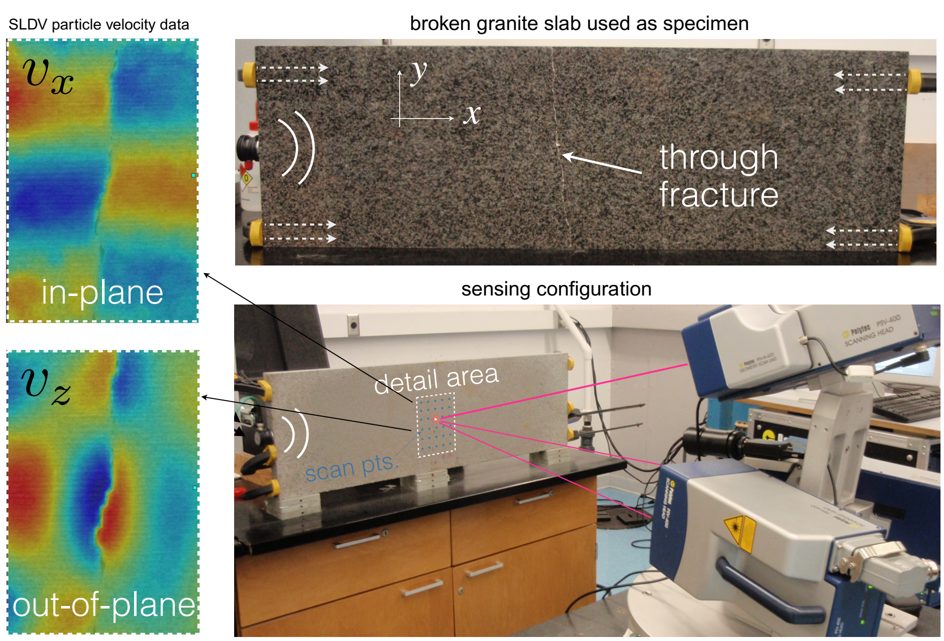
Geometric and interfacial properties of the *fractures and faults in rock* are the subject of critical importance to many facets of our society including mining, seismology, earthquake engineering, environmental protection, hydrogeology, and utilization of geothermal energy. One particular parameter embodying the fracture's interfacial condition is the so-called *specific stiffness*, quantifying for instance its rigidity under shearing or compression. Beyond its immediate relevance to the stability analyses in rock masses (e.g. during *mining operations*), the fracture specific stiffness has been found to: i) bear an intimate connection to the fracture's hydraulic properties (governing e.g. the performance of *enhanced geothermal systems*), ii) serve as a precursor of shear failure along rock discontinuities, and iii) help understand the mechanism of *shallow earthquakes*. In general, however, the fracture's response to given activation is equally driven by its geometry, which is inherently not limited to the planar condition. Thus a holistic characterization of subterranean fractures, that unveils both their *geometric* and *mechanical* characteristics, is a paramount.

In this vein, am looking for talented and highly motivated undergraduate students to take part in a *laboratory study* on seismic i.e. *ultrasonic* wave propagation through *partially-closed fractures* in rock.

SENSING CONFIGURATION

Seismic imaging of slab-like rock specimens containing either stationary or propagating fracture is considered, where the “illuminating” ultrasonic waves are generated by a piezoelectric transducer attached to the specimen’s boundary (see figure below). Thus generated ultrasonic wavefield is monitored i) over a grid of *interior* scan points covering the fracture, and ii) over the *outer* boundary of a rock slab. The motion measurements are performed in a non-contact fashion using *Scanning Laser Doppler Vibrometer* (SLDV) that takes advantage of the Doppler effect to measure three components of the particle velocity vector at every scan point over the rock surface.



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OBJECTIVES

The aim of this study is two-fold: i) to identify the *constitutive behavior* of the fracture interface directly from *interior* SLDV measurements — which is general could be nonlinear, anisotropic, and/or heterogeneous, and ii) to use, later on, such reconstructed “true” boundary condition to validate a hybrid *seismic imaging* approach (utilizing exclusively the *outer* SLDV measurements) that is capable of not only imaging the fracture geometry but also (indirectly) recovering its heterogeneous contact condition.

DUTIES

Depending on the need of the project and student’s affinities, undergraduate research duties may entail specimen preparation, ultrasonic measurements via SLDV, signal processing, and computational (finite element, boundary element) modeling of the underpinning wave propagation phenomena.

CONTACT

If you are interested in this research project, please contact me no later than *April 1, 2016*.

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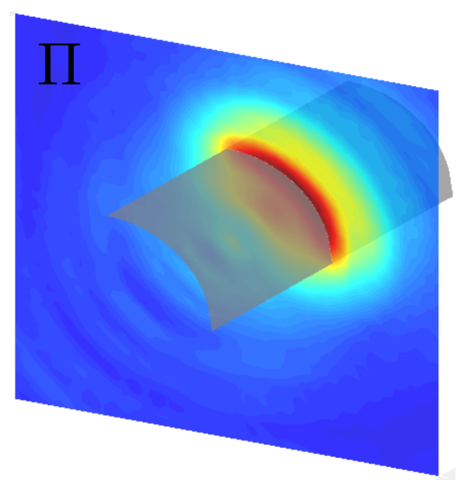

3D seismic image of a cylindrical hydraulic fracture, obtained by way of non-iterative waveform tomography

Waves & Imaging Lab at the University of Minnesota