Sounding of heterogeneous fractures in the subsurface

This talk highlights the development of a next-generation seismic imaging paradigm targeting the holistic characterization of hydraulic fractures in unconventional oil and gas reservoirs — that is capable of unveiling both their geometric and (heterogeneous) contact characteristics. First, two *non-iterative* approaches to the geometric reconstruction of fractures from the far field seismic data are considered in the context of inverse scattering. In addition to accomplishing the goal irrespective of the fracture's (unknown) contact condition, these wave-based reconstruction methods feature low sensitivity to measurement noise and impose far less restrictions on the seismic sensing configuration relative to existing non-iterative solutions. Such advancements are then deployed, in the second step of the holistic inverse solution, to help decipher the contact law on the surface of heterogeneous fractures. In order to validate the proposed sensing framework, a laboratory setup has been developed wherein slab-like laboratory rock specimens are imaged ultrasonically while being fractured in a three-point-bending configuration. At a number of stages along the (static) loading curve, the fracturing of rock is arrested by holding the crack mouth opening displacement constant, while "illuminating" the interior of a specimen by ~30 kHz ultrasonic waves. In this setting, the induced wave motion on the boundary of slab is captured in a non-contact fashion via a 3D Scanning Laser Doppler Vibrometer that is capable of tracking triaxial (and thus in-plane) particle velocity with nanometer accuracy and millimeter spatial resolution. The acquired data are then used to validate the inverse scattering solution developed earlier.