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Seismic imaging in laboratory trough laser Doppler vibrometry

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Mimic near-surface seismic field measurements at a small scale, in the laboratory, under a well-controlled environment, may lead to a better understanding of wave propagation in complex media such as in geological materials. Laboratory experiments can help in particular to constrain and refine theoretical and numerical modelling of physical phenomena occurring during seismic propagation, in order to make a better use of the complete set of measurements recorded in the field.
We have developed a laser Doppler vibrometer (laser interferometry) platform designed to measure non-contact seismic displacements (or velocities) of a surface. This technology enables to measure displacements as small as a tenth of a nanometer on a wide range of frequencies, from a few tenths to a few megahertz. Our experimental set-up is particularly suited to provide high-density spatial and temporal records of displacements on the edge of any vibrating material.
We will show in particular a study of MHz wave propagation (excited by piezoelectric transducers) in cylindrical cores of typical diameter size around 10 cm. The laser vibrometer measurements will be first validated in homogeneous materials cylinders by comparing the measurements to a direct numerical simulation. Special attention will be given to the comparison of experimental versus numerical amplitudes of displacements. In a second step, we will conduct the same type of study through heterogeneous carbonate cores, possibly fractured. Tomographic images of velocity in 2D slices of the carbonate core will be derived based upon on the time of first arrival. Preliminary attempts of tomographic attenuation maps will also be presented based on the amplitudes of first arrivals. Experimental records will be confronted to direct numerical simulations and tomographic images will be compared to x-ray scanner imaging of the cylindrical cores.