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Reproduction of large-scale seismic exploration at laboratory-scale with controllable sources is a promising approach that could not only be applied to study small-scale physical properties of the medium, but also contribute to significant progress in wave-propagation understanding and complex media imaging at exploration scale via upscaling methods. We seek to characterize the properties of a laser-generated source for new geophysical experiments at laboratory scale. This consists in generating seismic waves by pulsed-laser impacts and measuring the displacement wavefield by laser vibrometry. Parallel 2D/3D simulations using Discontinuous Galerkin discretization method and analytic predictions have been made to test the experimental data.

**Research context & objectives**

On the use of a pulsed-laser source in laboratory seismic experiments

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**Pulsed-laser source : General**

Lab set-up for pulsed-laser source characterization

Two different experimental tools were mounted to investigate in Cartesian coordinates or in cylinder coordinates. (2) Q-switched laser generator: (3) convergent lens: (4) Aluminum foil samples of various thickness (10, 50, 100 mm), Vp = 6000 m/s, V s = 2Vp. (5) single-point Laser Doppler Vibrometer (LDV). (6) six sample: (7) piezoelectric source.

Theoretical and analytical signals

**Pulsed-laser source : Seismogram**

Seismogram and radiation patterns

Regime evolution with d under constant input energy. Since the spot size depends on d, the observable regime cannot be determined universally by \(p_2\).

Seismogram measured along linear receivers on the 50 mm thick aluminum block with different sources, accompanied by simulated/modeled radiation patterns: a) radiation pattern of a point source (thermocouple); b) radiation pattern of a piezoelectric source (d = 10mm); c) radiation pattern of a typical thermocouple source (d = laser irradiation).

**Epicentral records under the ablation regime**

Source stability and reproducibility

**Pulsed-laser source : Application**

First arrival time base tomography

Toward Full Waveform Inversion (FWI) ?

The idea of Full Waveform Inversion (FWI) is to perform a quantitative reconstruction of the medium parameters. The inversion process reduces the difference between the observations and simulations, in order to resolve the medium parameters more directly. The quality of the inversion process is judged with the residual, in a symmetric manner. The objective is to test the ability of the code to perform full waveform inversion on real seismic data.

References

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Conclusion:

This laser-generated source opens new perspectives on various applications such as precise Non-Destructive Test on metals under high temperatures, monostatic seismic exploration on small and intermediate scale samples of random shapes in the laboratory etc. We are especially interested in testing geophysical applications in rock mechanics, rocks or digital rock imaging for geological reservoirs explorations. The laser-generated source appears to be well controllable, flexible and reproducible under some precautions. The combination of this pulsed laser source and the LDV is particularly adapted to generate broadband seismic full waveforms in heterogeneous natural rocks, for novel imaging applications in geological explorations.