On the use of a pulsed-laser source in laboratory seismic experiments
Chengyi Shen, Daniel Brito, Julien Diaz, Deyuan Zhang, Clarisse Bordes, Florian Faucher, Stéphane Garambois

To cite this version:
Chengyi Shen, Daniel Brito, Julien Diaz, Deyuan Zhang, Clarisse Bordes, et al.. On the use of a pulsed-laser source in laboratory seismic experiments. AGU meeting 2018, Dec 2018, Washington, United States. <hal-01957147>
On the use of a pulsed-laser source in laboratory seismic experiments

C. Shen1,2, D. Brito1,2, J. Diaz2, D. Zhang1, C. Bordes1, F. Faucher1,2, S. Garambois1

1) CNRS/ TOTAL / Univ Pau & Pays Adour/E2S UPPA, Laboratoire des Fluides Complexes et leurs Réservoirs – IPIRA, UMR5150, 64000, Pau, FRANCE
2) Univ Pau & Pays Adour/CNRS, Laboratoire de Mathématiques et de leurs Applications, UMR5142, 64000, Pau, FRANCE
3) Project Team Magique-3D, Inria Bordeaux-Sud-Ouest, 64013 Pau, France
4) Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNHS, I3D, IFSTTAR, ISTerre, UMR5275, 38000 Grenoble, France

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 seismic source for new geophysical experiments at laboratory scale. This consists in generating seismic waves by pulsed-laser impacts and measuring the displacement waveform by laser vibrometry. Parallel 2D/3D simulations using Discontinuous Galerkin discretization method and analytic predictions have been done to match the experimental data.

Pulsed-laser source : General

Lab set-up for pulsed-laser source characterization

Two different experimental tools were mounted in order to perform experiments in cylindrical coordinates : 1) Discontinuous Galerkin generator ; 2) convergent lens ; 3) aluminium pulsed samples of various thickness (10, 50, 100 mm), Vp ≈ 6000 m/s Vp ≈ 6000 m/s ; 4) single-point Laser Doppler Vibrometer (LDV) ; 5) test sample ; 6) piezoelectric source.

Theoretical and analytical signals

a) Laser-generated seismic wave under thermodiffusive regime with displacement computed by combining the wave equation and the thermodiffusive equations [2, 3, 5]. b) Laser-generated seismic wave under ablation regime which is modeled as a point-source [3].

Zoom on the measured ablation-regime pulse

Examples of recorded signals obtained with laser-irradiation: a) temporal laser-generated source S0, retrieved from a record on the 50 mm thick aluminium block ; b) frequency spectrum $S_0$ of the same source ; c) First order time derivative of $S_0$, thus showing the surface vibration velocity ; d) Frequency spectrum of $S_0$.

Distribution of first arrival seismic wave amplitudes $a$, measured by LDV at the center of the 10 mm thick aluminium block. $P_0$ denotes the incident power density.

Conclusion:

This laser-generated seismic source opens new perspectives on various applications such as novel Non-Destructive Test on metals under high temperatures[8], non-invasive exploration on small and intermediate scale samples of random shapes in the laboratory etc. We are especially interested in its potential applications in rock mechanics[6], rocks or digital rock imaging for geological reservoir explorations. The laser-generated source is shown to be well controllable, flexible and reproducible under some precautions. This is particularly adapted to generate broadband seismic full waveforms in heterogeneous natural rocks.

References