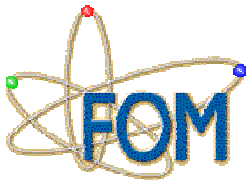
Sound wave propagation in granular materials

O. Mouraille, S. Luding
Multi-Scale-Mechanics / TS / CTW / UTwente

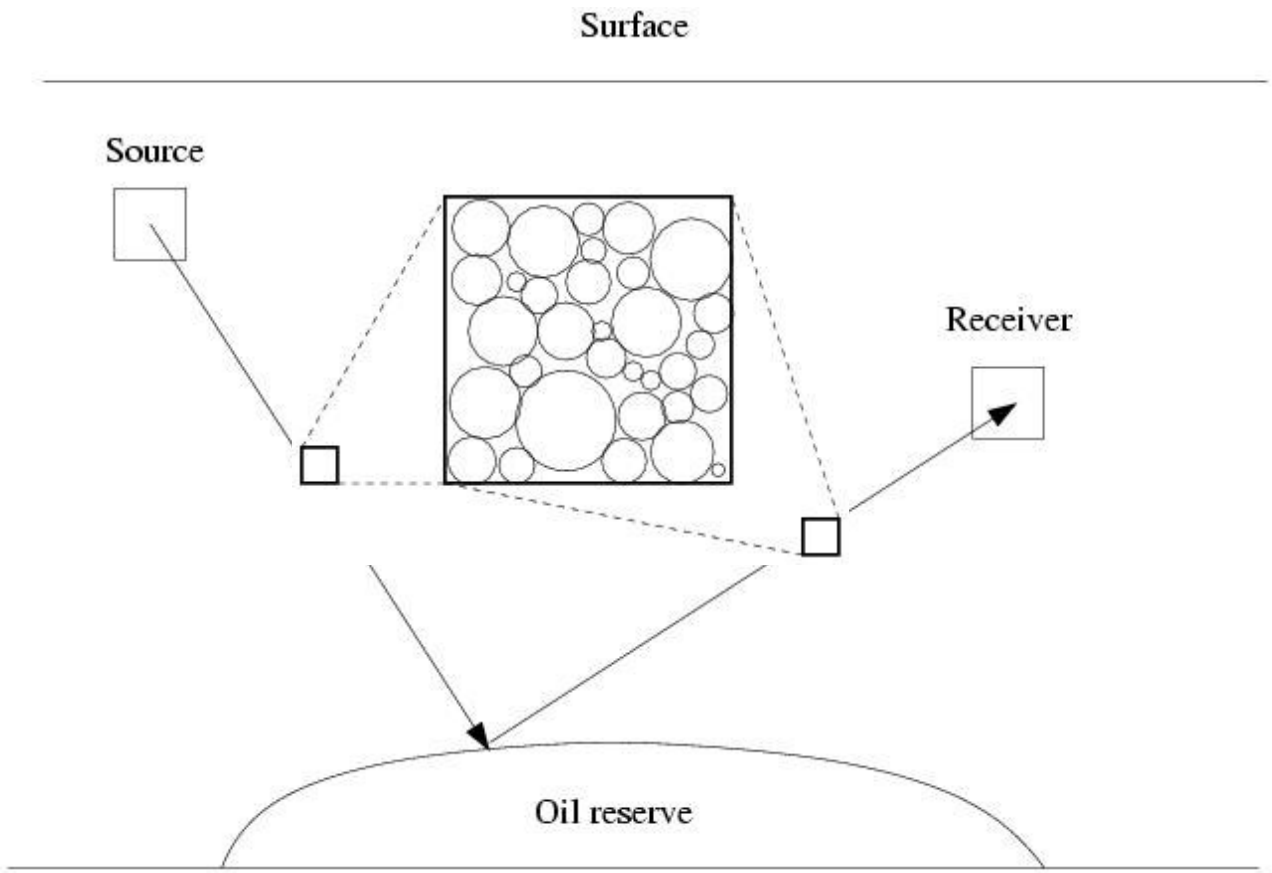


Applications

- Seismology

- Oil exploration

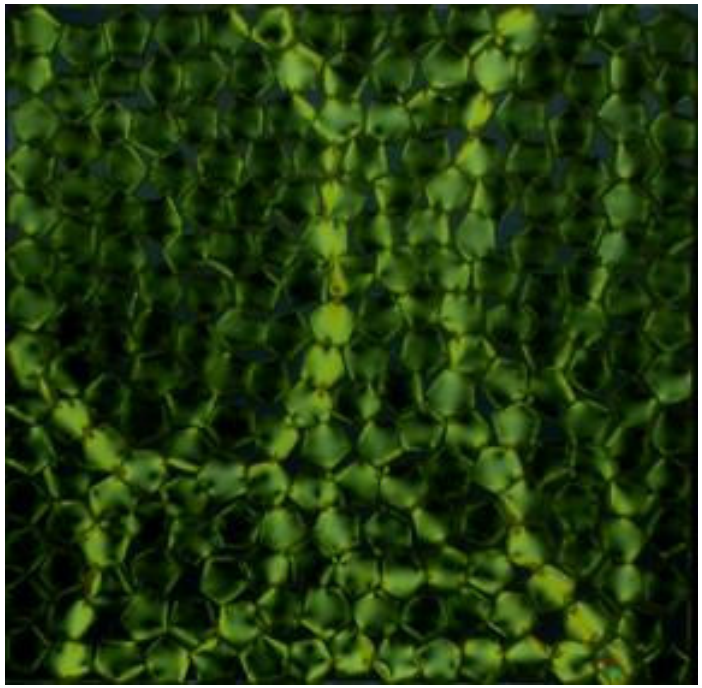
- …



Granular matter

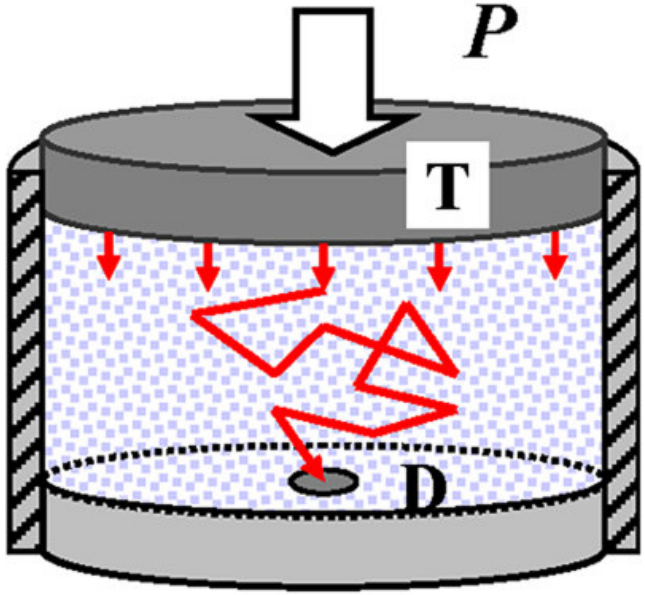
Assembly of grains:

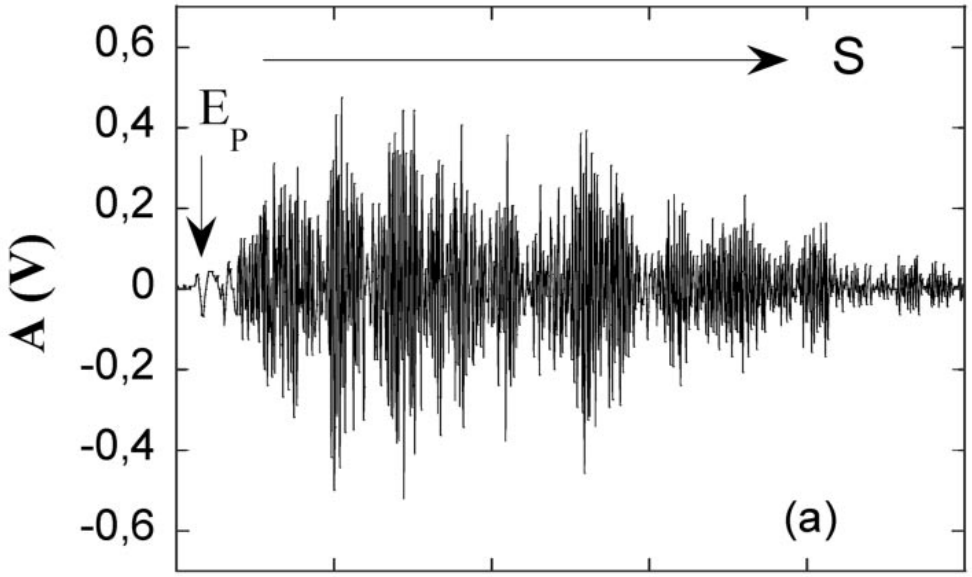
- Dense
- Friction (Rotations)
- Inhomogeneous
- Non-linear behaviour



Codalike Multiple Scattering of ElasticWaves in Dense Granular Media

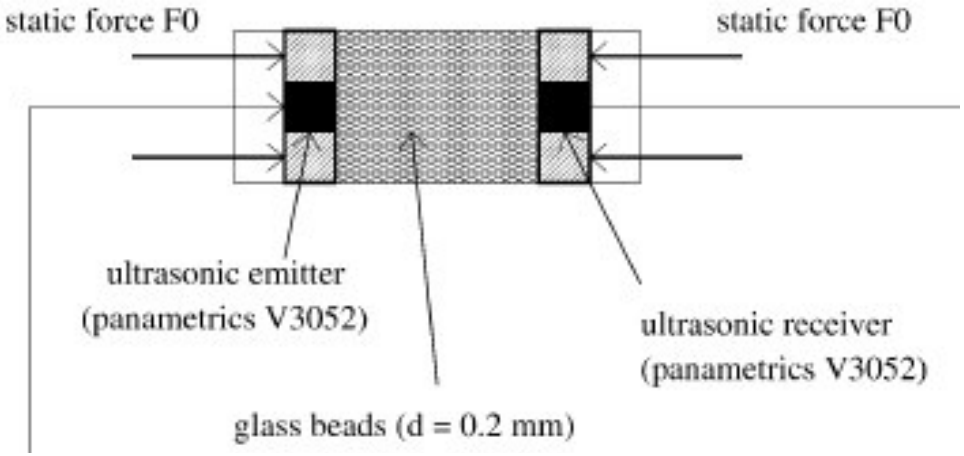
X. Jia, PRL, 2004

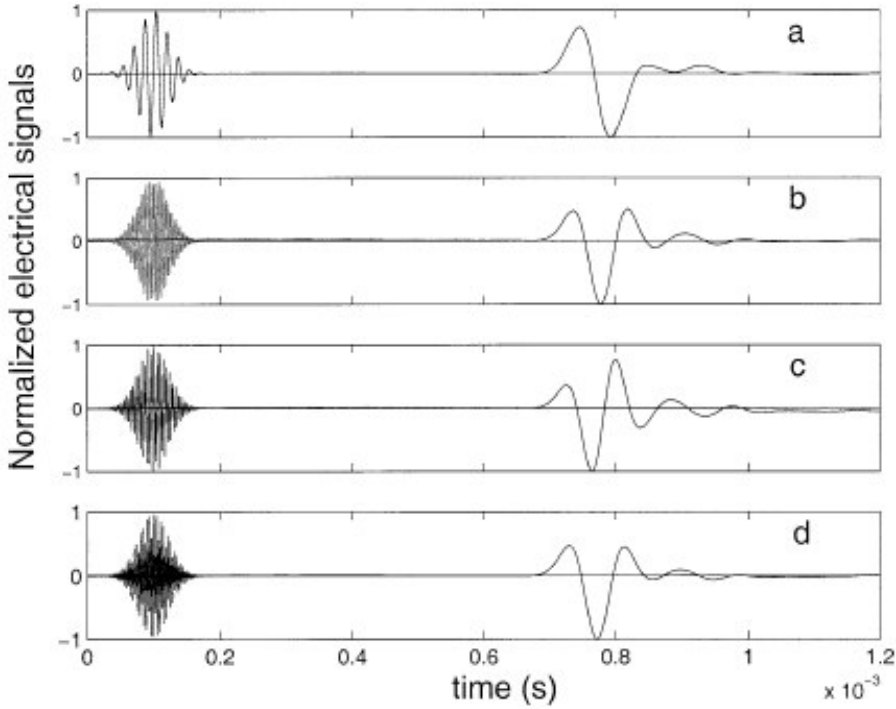




Self-demodulation acoustic signatures for nonlinear propagation in glass beads

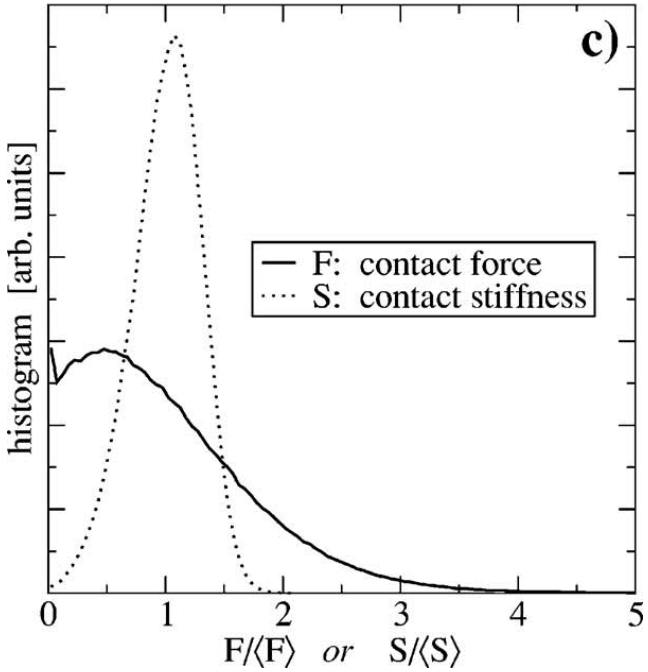
V. Tournat et *al*, C.R.Mecanique, 2002

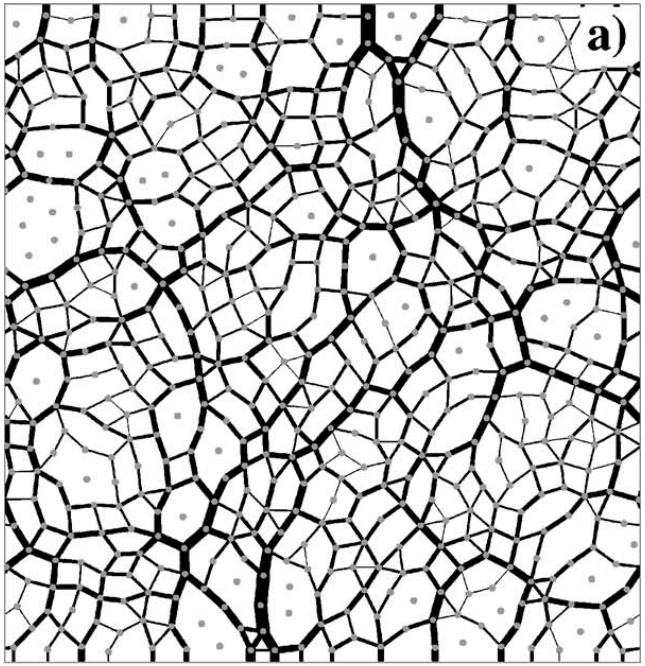


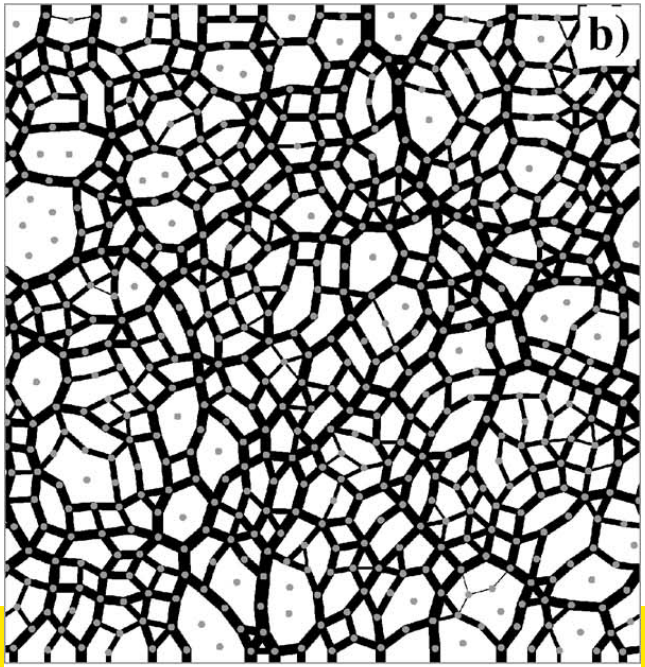


Elastic wave propagation in confined granular systems

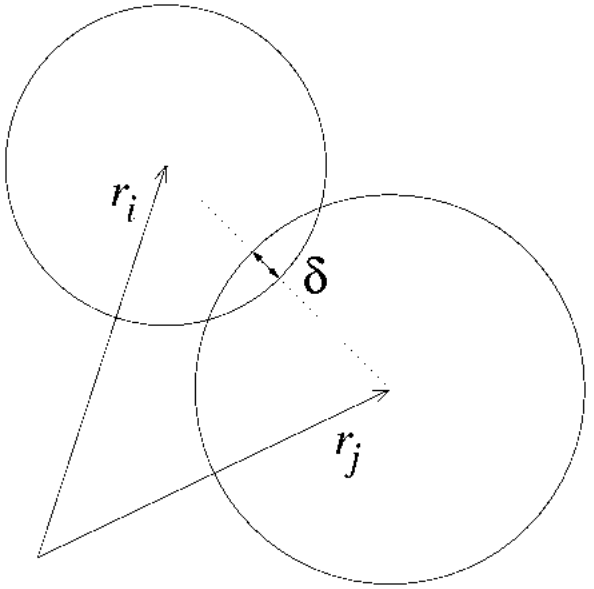
Somfai et al, Phys. Rev. E, 2005







Discrete Element Method

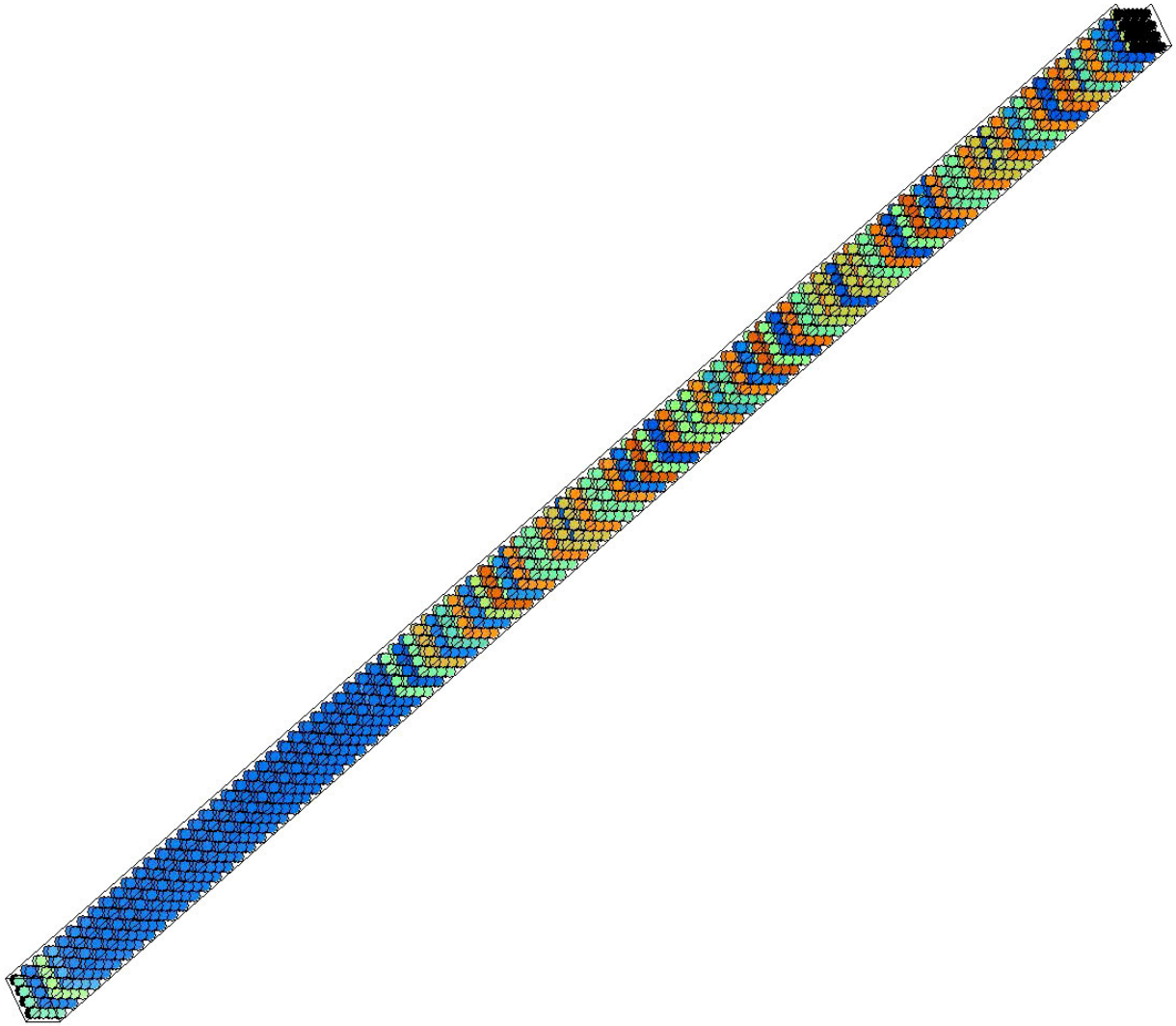


The equation of motion is solved for all particles according to the contact forces and torques.

- *Normal part :* $f = k_N . \delta$ ***repulsive*** and *attractive* forces (**dissipation**)

- *Tangential part :* ***Sliding*** **-(**$\boldsymbol{k_T}$**)**, *Rolling*- and *Torsion*- resistance

P-wave animation



Towards complexity

Modes

- P-waves
- S-waves
- R-waves
- …

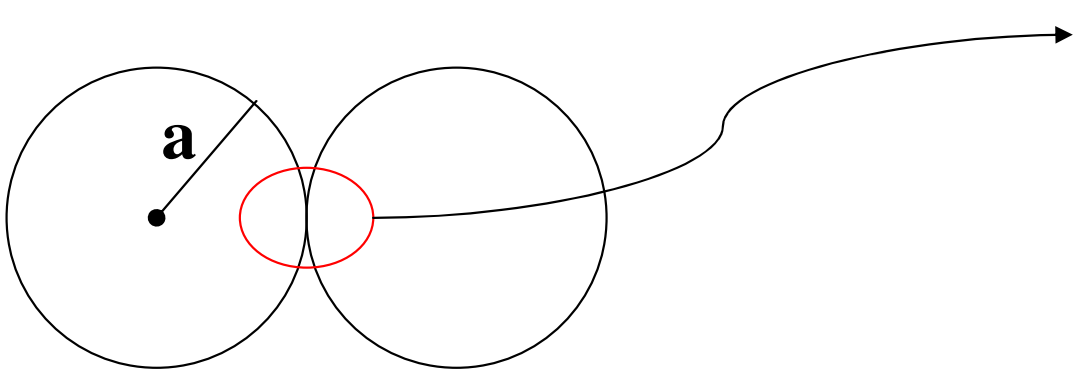
Micro-Parameters

- Damping
- Friction (Rotations)
- Cohesion
- Contact law
- …

Structure

- Mono- poly-disperse
- (Dis-)ordered
- …

Weak polydispersity



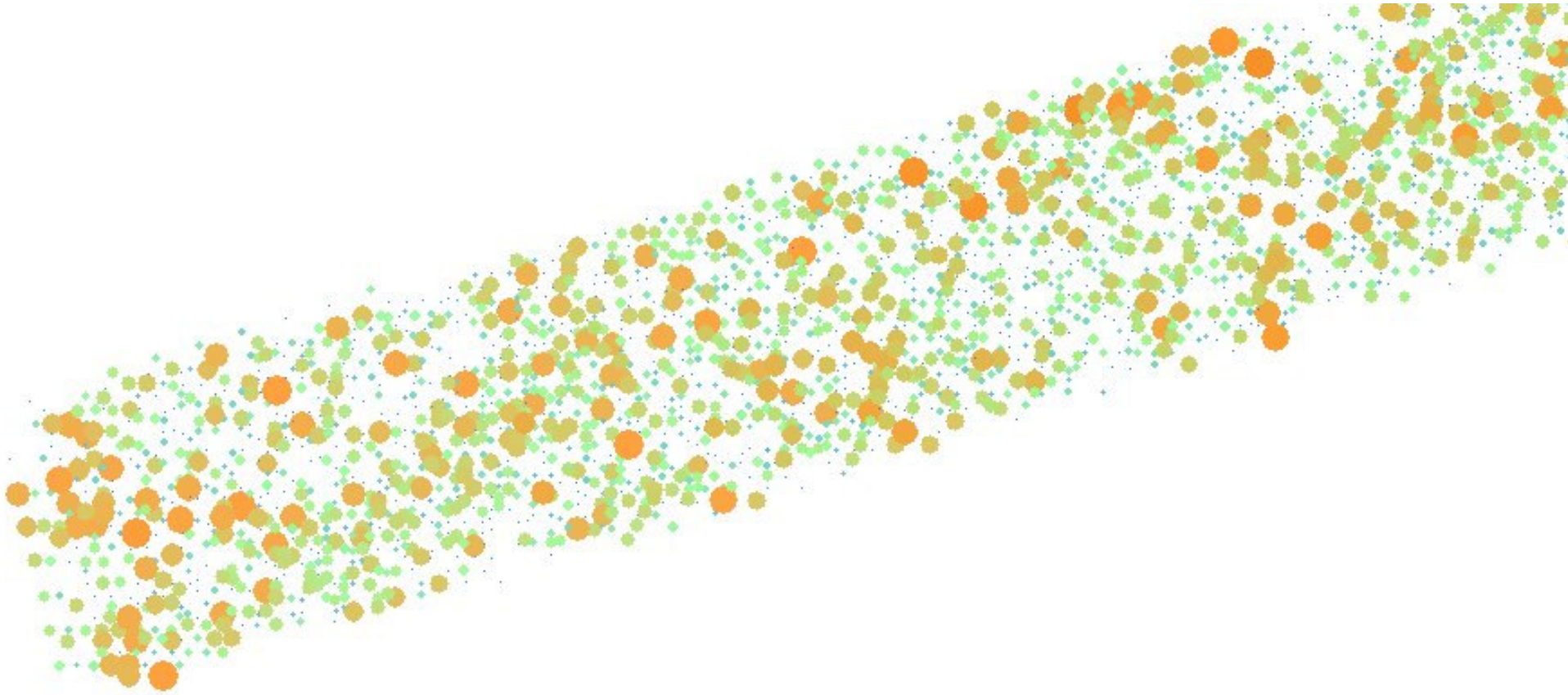
$\delta = a/1000$

$\Delta a = \delta/2, \delta$ and 2δ

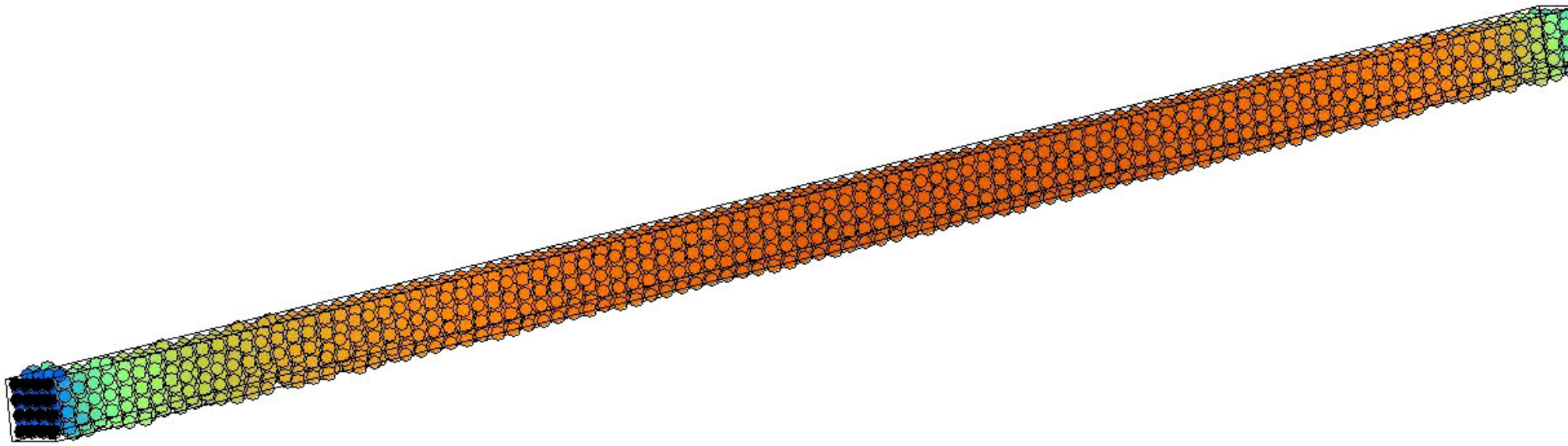
-The system is practically unchanged at the grain level

-Distribution of weak and strong contacts
and most important opening of contacts

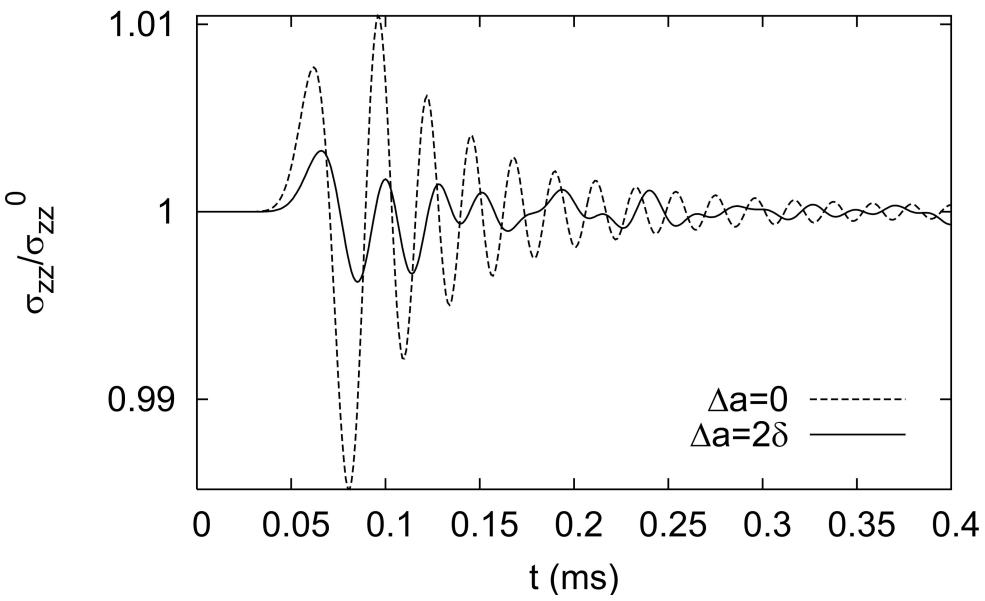
Contacts



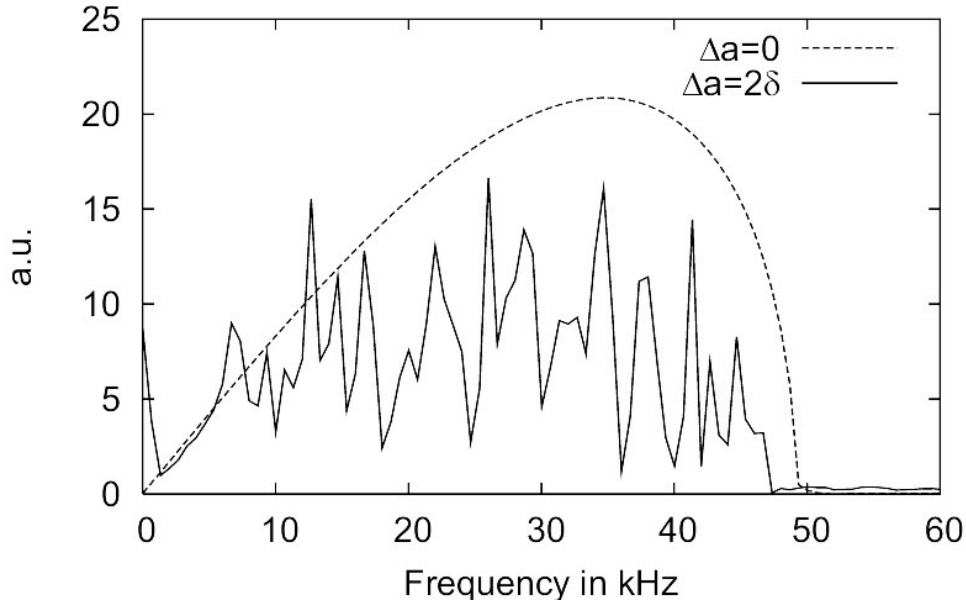
P-wave animation



Signals Analysis

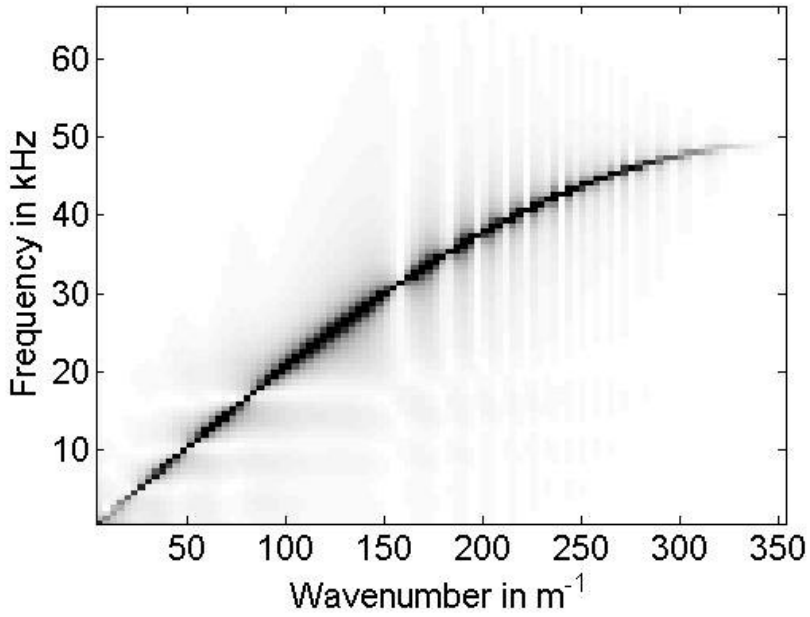


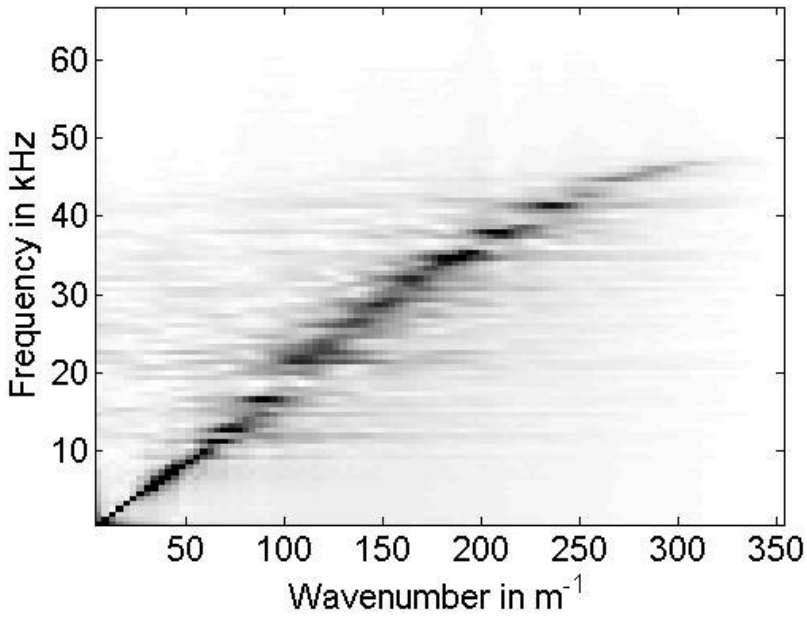
Stress-time signal



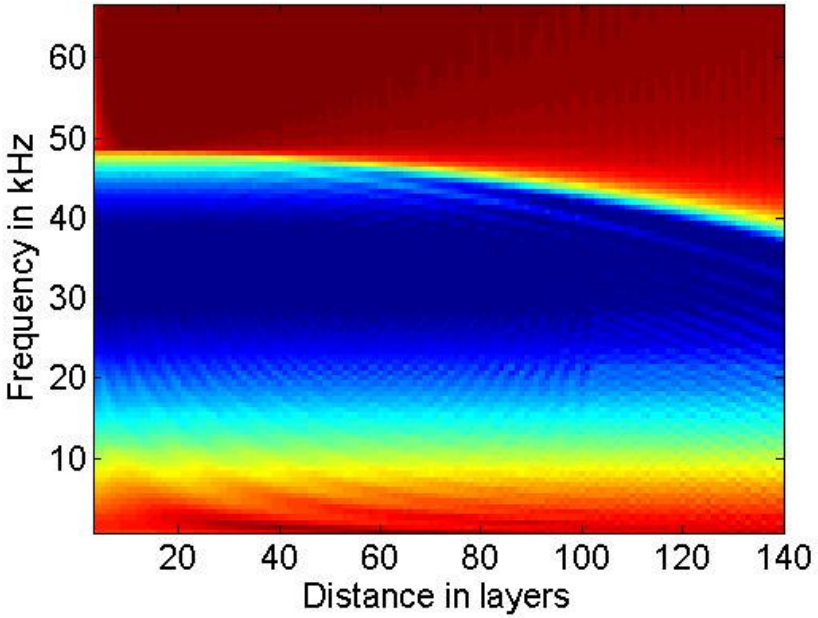
Power-spectrum

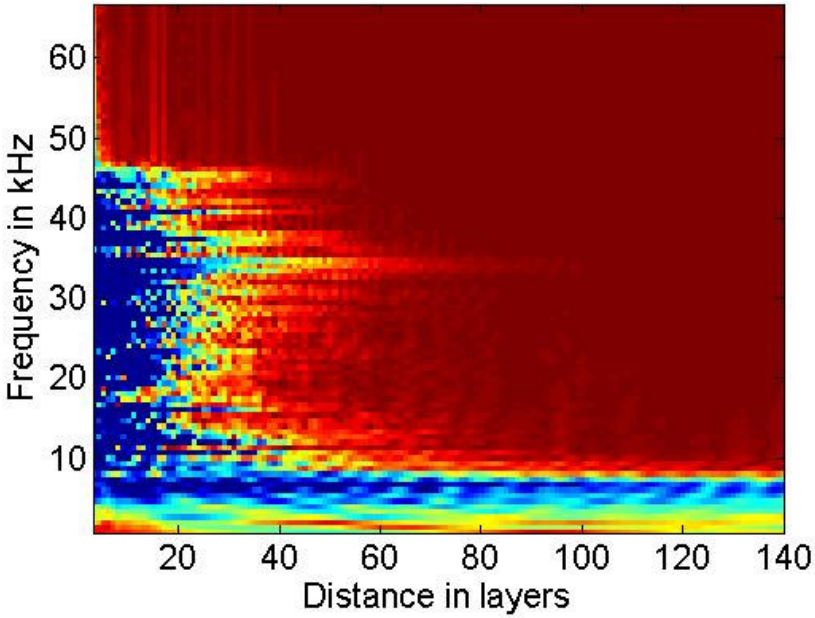
Dispersion relations



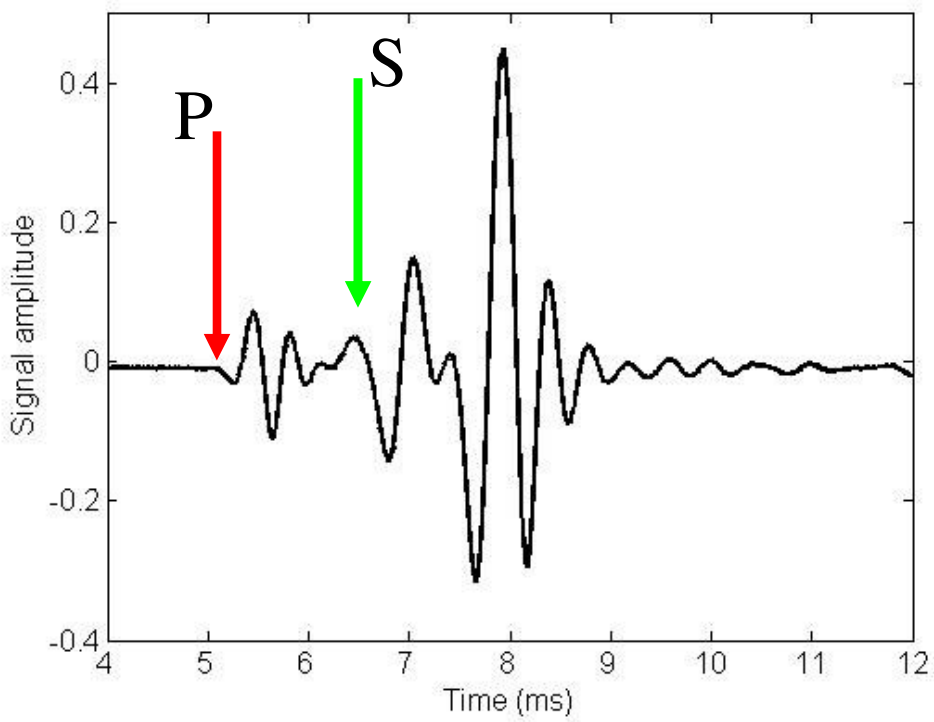


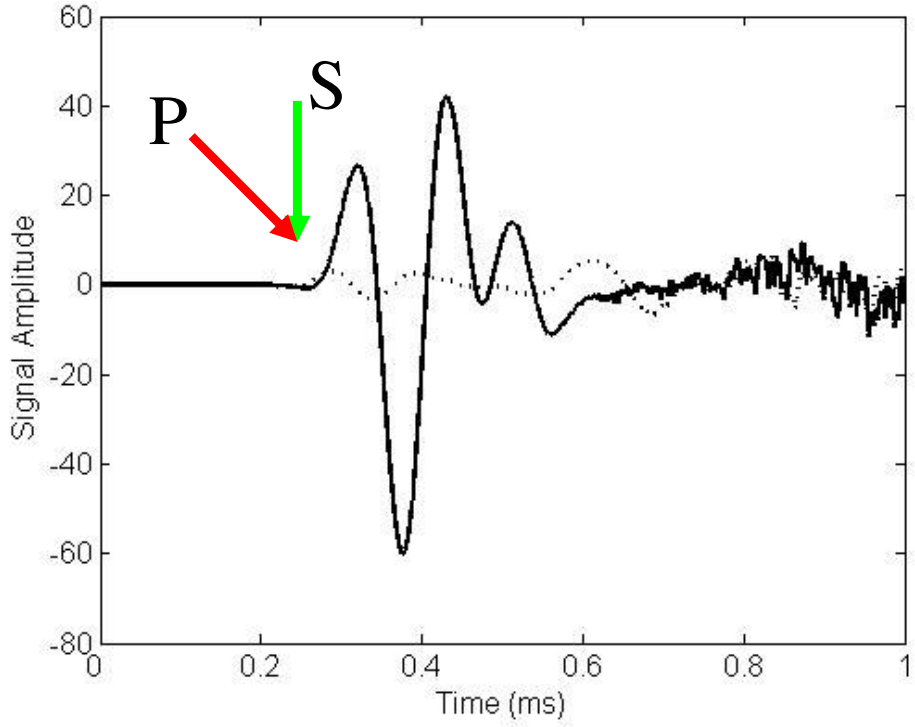
Frequency-space Diagrams





Experiment versus Simulation





Conclusions

- The model is able to mimic some well-known phenomena of the wave propagation in granular matter.
- When complexity increases not all features are understood, however in some cases the influence of parameters is characterized.

Perspectives

- What is predictable from the initial system?

Micro-parameters and structure >Macro/continuum

- Experiments