Seismic source under tensional regime - the DEM approach

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Motivation

The classical approach to study breaking process at seismological scales, i.e., physical processes in earthquake foci, is essentially based on:

- **seismic data** (mostly)
- **continuum mechanics** (including the linear fracture mechanics).

This approach has been highly successful in developing kinematic (first) and dynamic (recently) models of seismic rupture and explaining many features of earthquakes.
Motivation

However, sooner or latter it will face a serious limitations:

- finite information content of seismic data.
- limitations of the fracture mechanics.

To release these limitations we propose to enhanced our seismic source analysis by computational simulations a powerful tool of contemporary physics.
Numerical simulations

Which numerical method should be used?
Breaking and fragmentation of solid materials is an extremely complex process over scale range:

- **Size:**
  \[10^{-10} - 10^6 \text{ m}\]

- **Energy:**
  \[10^{-19} - 10^{22} \text{ J}\]
Scales mixture
Basic features

1. Breaking is always accompanied by creating new free surfaces (fracturing, fragmentation, void openings).

2. Breaking process always includes some degree of stochasticity.
The most important characteristic of breaking processes is creating of a new free surfaces (fracturing, fragmentation). Used simulation method should encapsulated this feature of analyzed processes.

- **Discrete Element Method**
- **Boundary Element Method**
- hybrid Finite Element Method
Discrete Element Method

\[ u_i(t + dt) = u_i(t) + F(u_j(t)) dt \]
Simulation - a thin film under tension
Simulations - slow loading
Simulations - fast loading
Simulations - loading speed effect
Simulations - loading speed effect cd.

Nonlinear transferring of external load to the total kinetic energy of particles
Simulation - The Brazilian test
Simulations

Particle size: $R_{\text{max}} = 0.2\text{mm}$, $R_{\text{min}} = 0.03 - 0.1\text{mm}$,
Simulations: load-strain
Simulations: kinetic an potential energy

![Graphs showing kinetic and potential energy simulations](image)
Simulations: surprising linearity

\[ \gamma = \frac{R_{\text{max}}}{R_{\text{min}}} - P_{\text{max}} - d_c - E_{\text{pot max}} \]
Conclusions

Numerical simulation can provide “missing” information on kinematics and (the most interesting) dynamics of processes in seismic foci
Thank you

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