10828

Bridging the gap between particulate systems and continuum theory

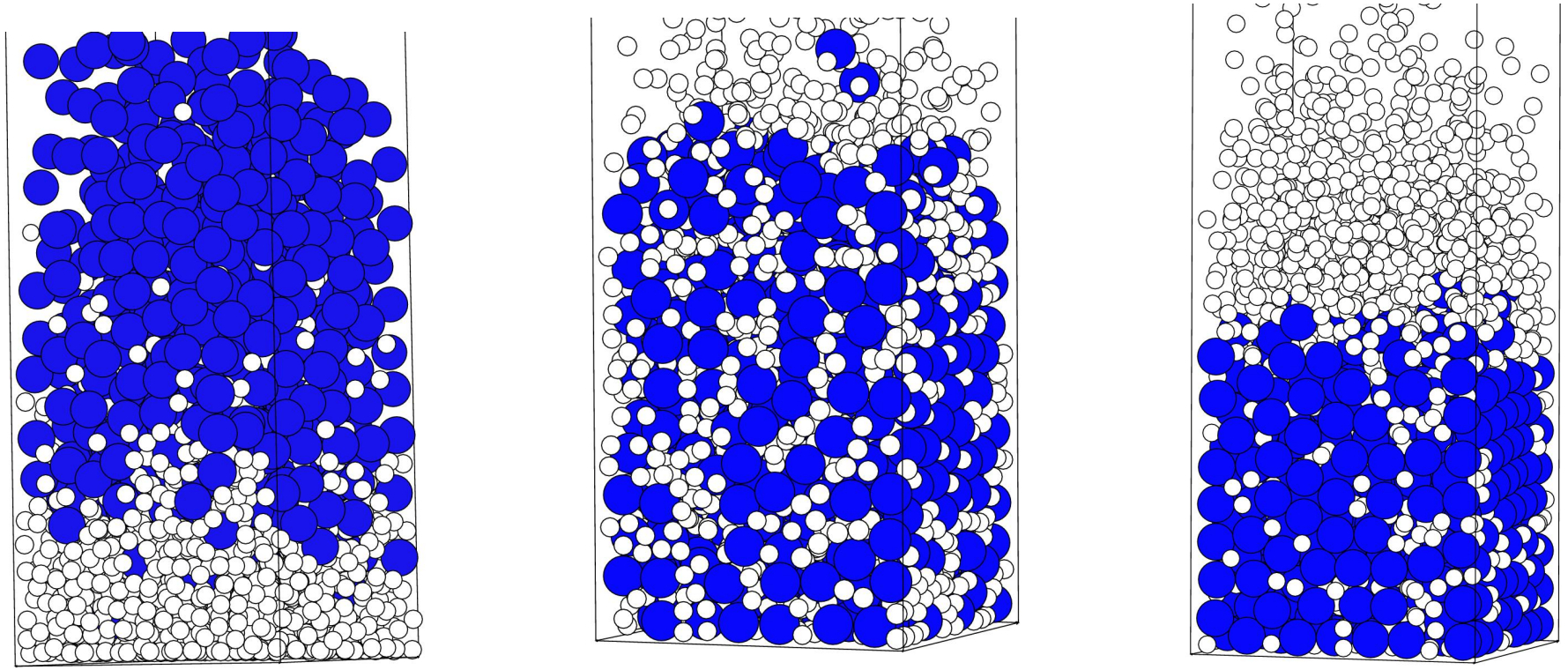
Stefan Luding, MSM, CTW, UTwente, NL

NWO stw *VICI 2011,12,13,…* msm

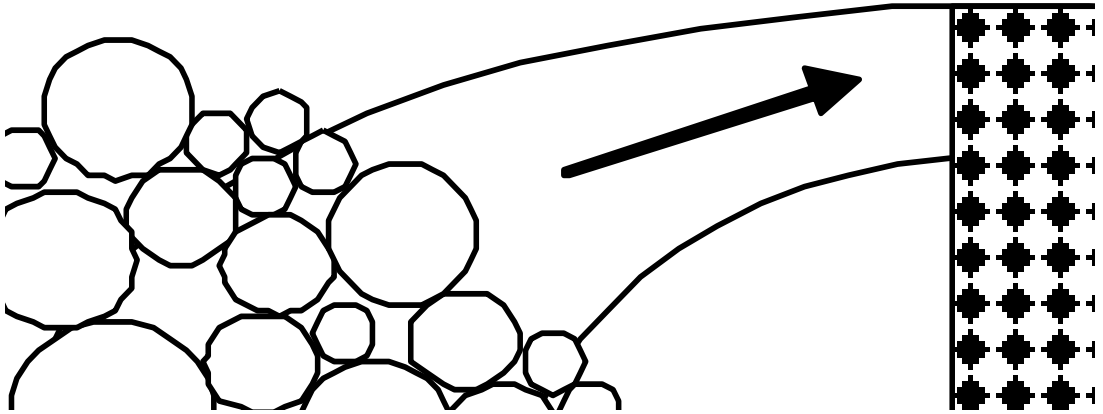
soil, sand,
powders,
concrete,
ceramics,
cells, blood,
…

particulate systems

Example: Segregation/Mixing



P. V. Quinn, D. Hong, SL, PRL 2001



Bridging the **gap** between
particulate systems
from microscopic understanding
and continuum theory
towards macroscopic applications

NWO stw *VICI 2009*

msm

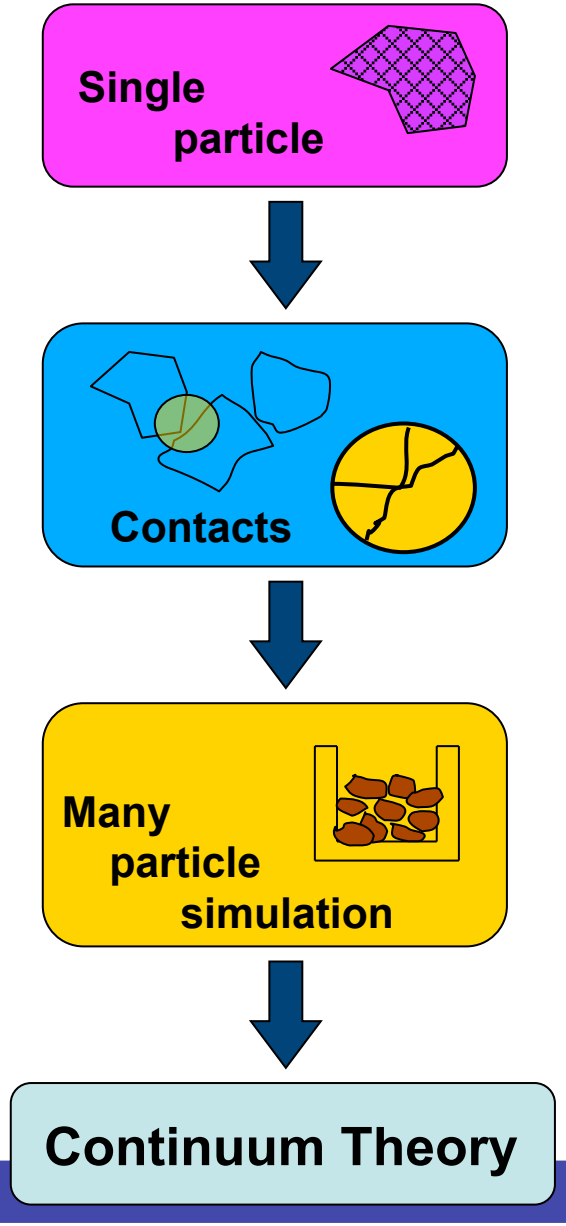
Why?

- Particle Methods (Micro-Details)
- Method: Micro-Macro Transition
- Continuum Theory (Applications)

Continuum Theory

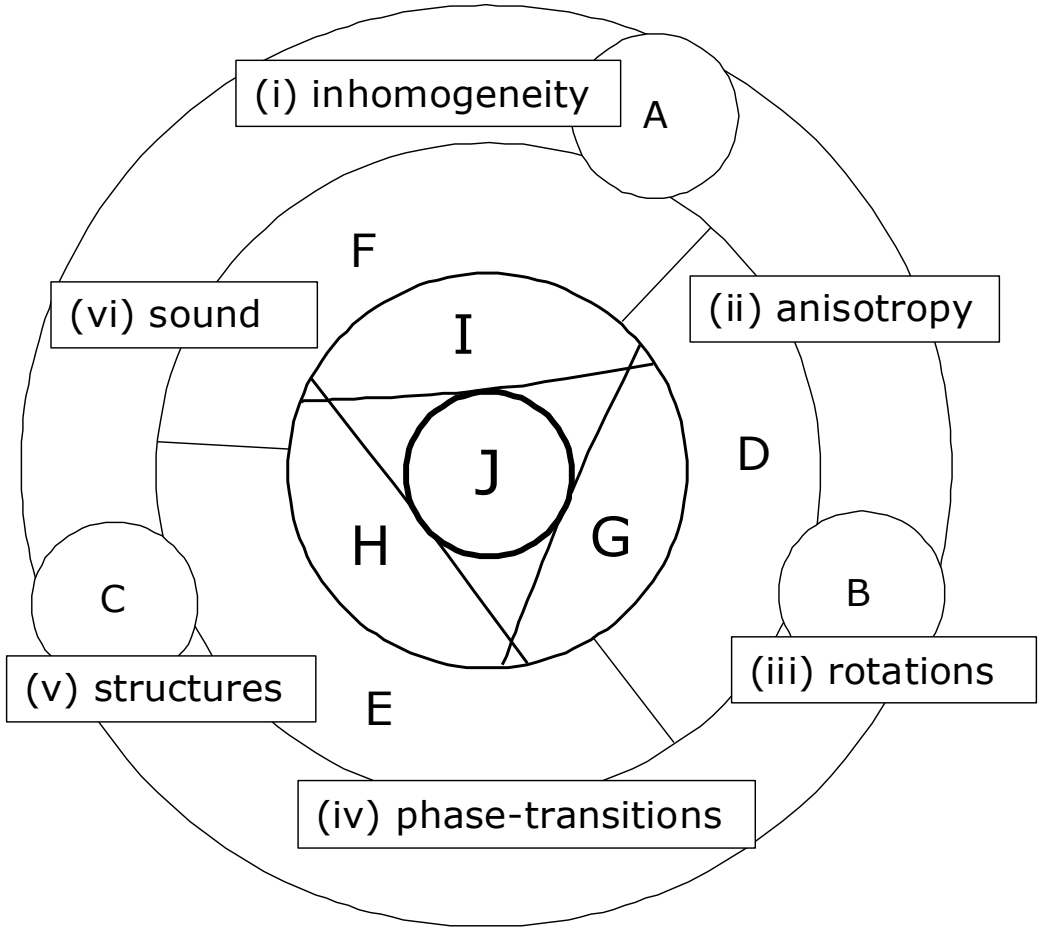
Approach

- Particle Methods
- Micro-Macro Transition
- Towards Continuum Theory
- Applications



Topics ...

- inhomogeneity
- anisotropy
- rotations
- phase-transitions
- structures
- sound
- ...



Topics ...

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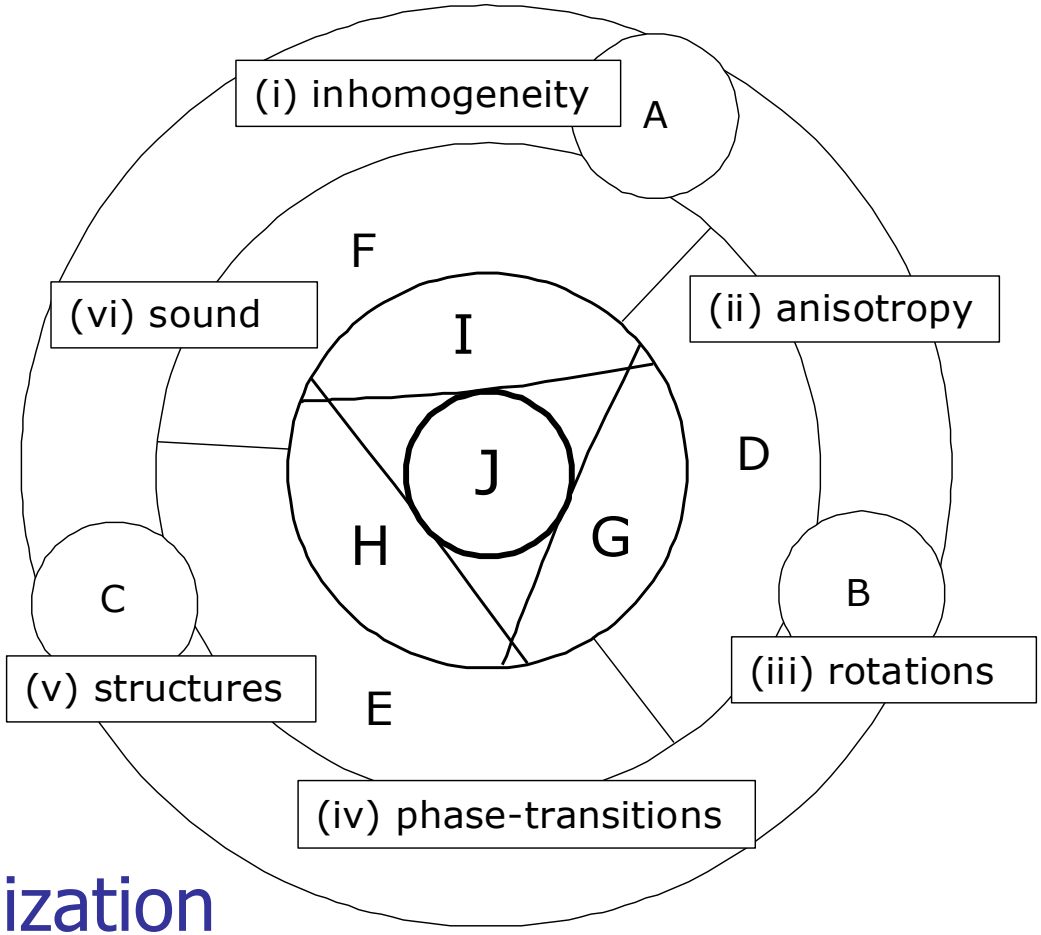
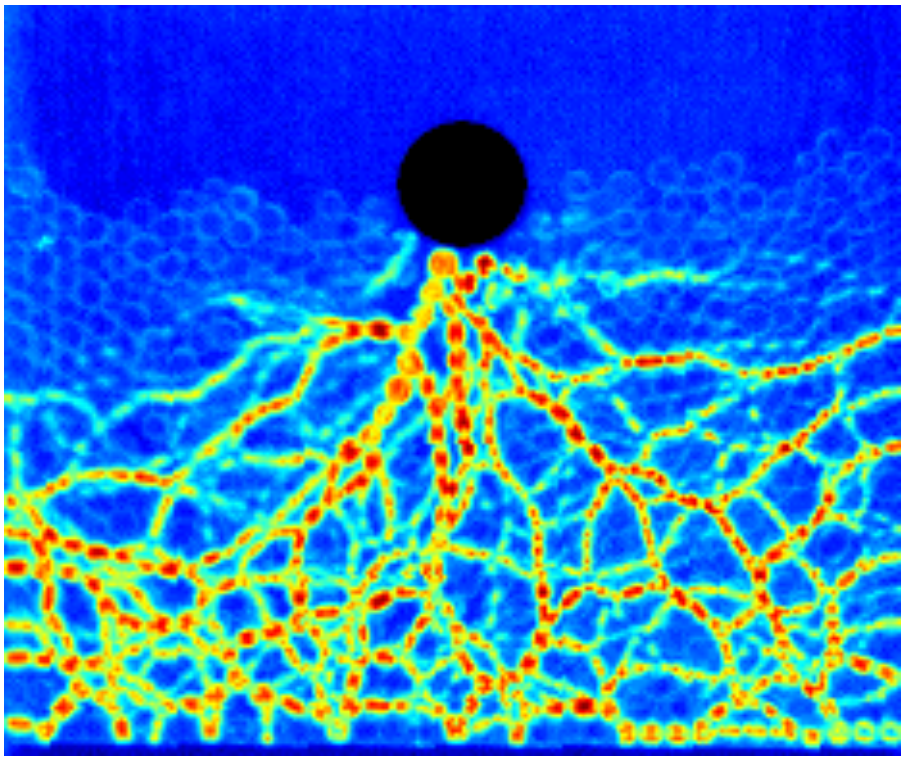
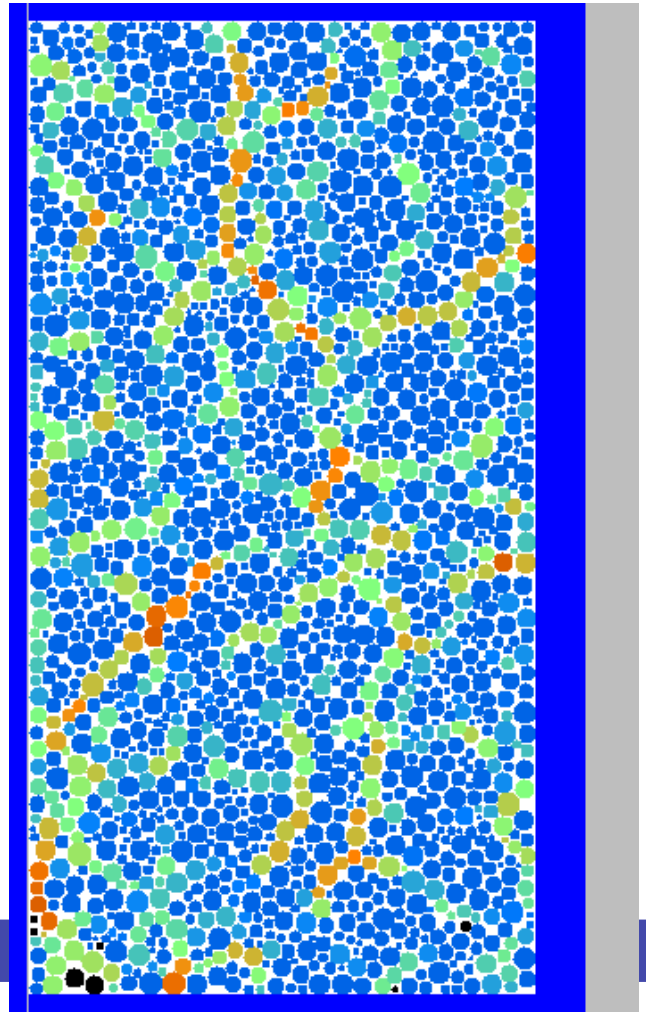


Example:

Instability &
Shear band Localization

Force-chains
experiments - simulations





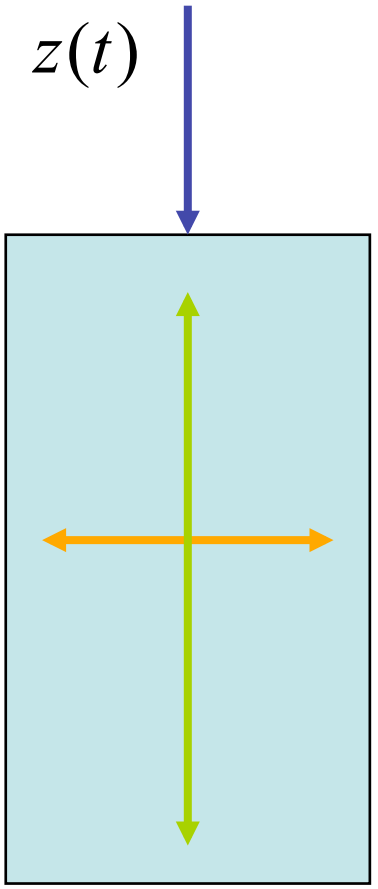
2D Exper. Behringer, Duke, USA

... 3D Exp. Sperl, DLR, Germany

Biaxial box set-up

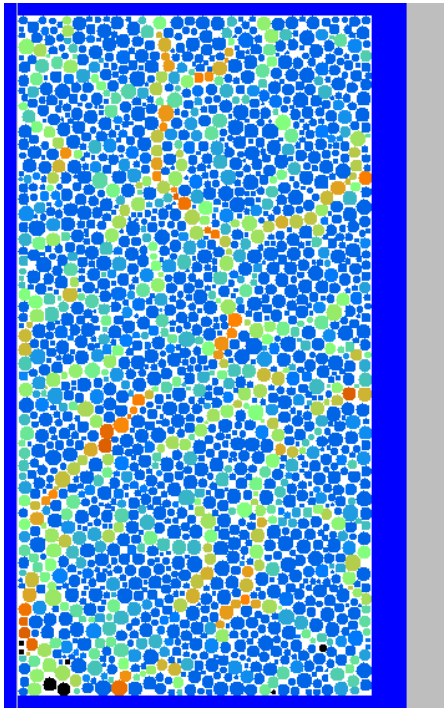
- Top wall: strain controlled
- Right wall: stress controlled

$\sigma_{xx} = \text{const.}$ →

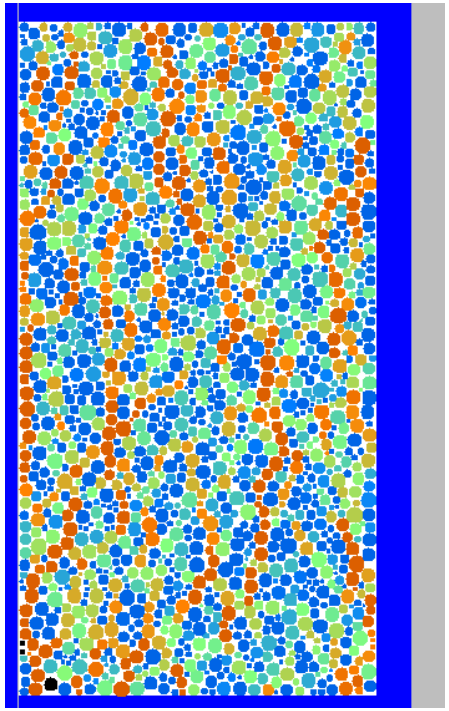


Simulation results (closer look)

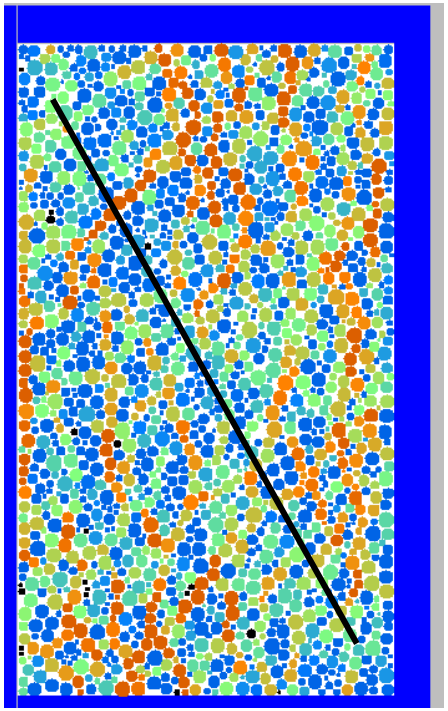
ε_{zz}=0.0%



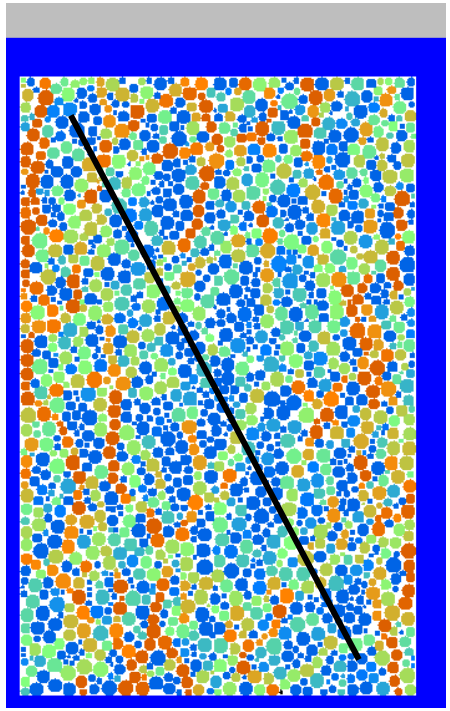
ε_{zz}=1.1%



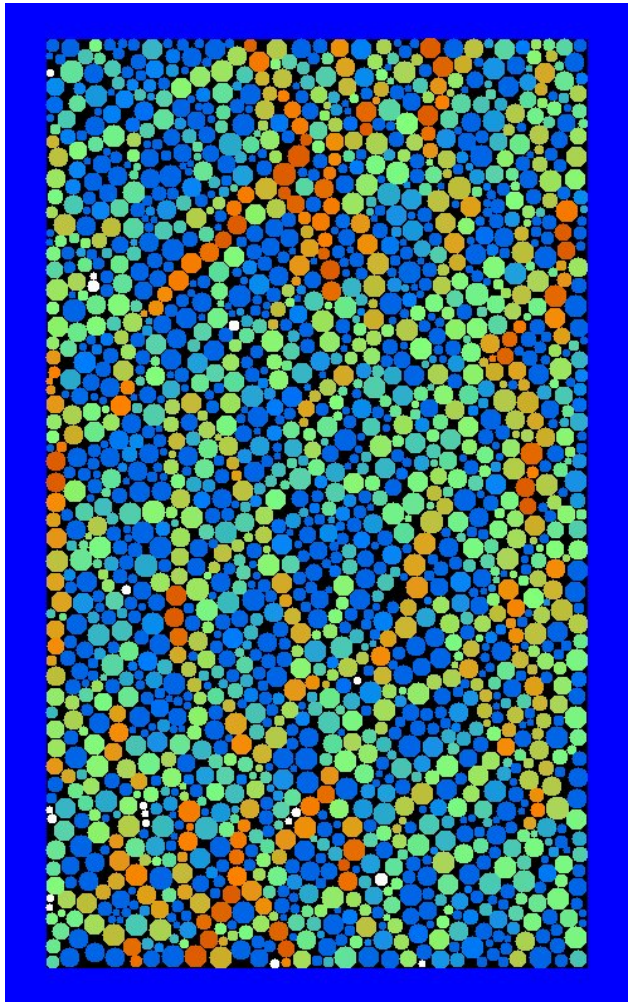
ε_{zz}=4.2%



ε_{zz}=9.1%



Bi-axial box (stress chains)



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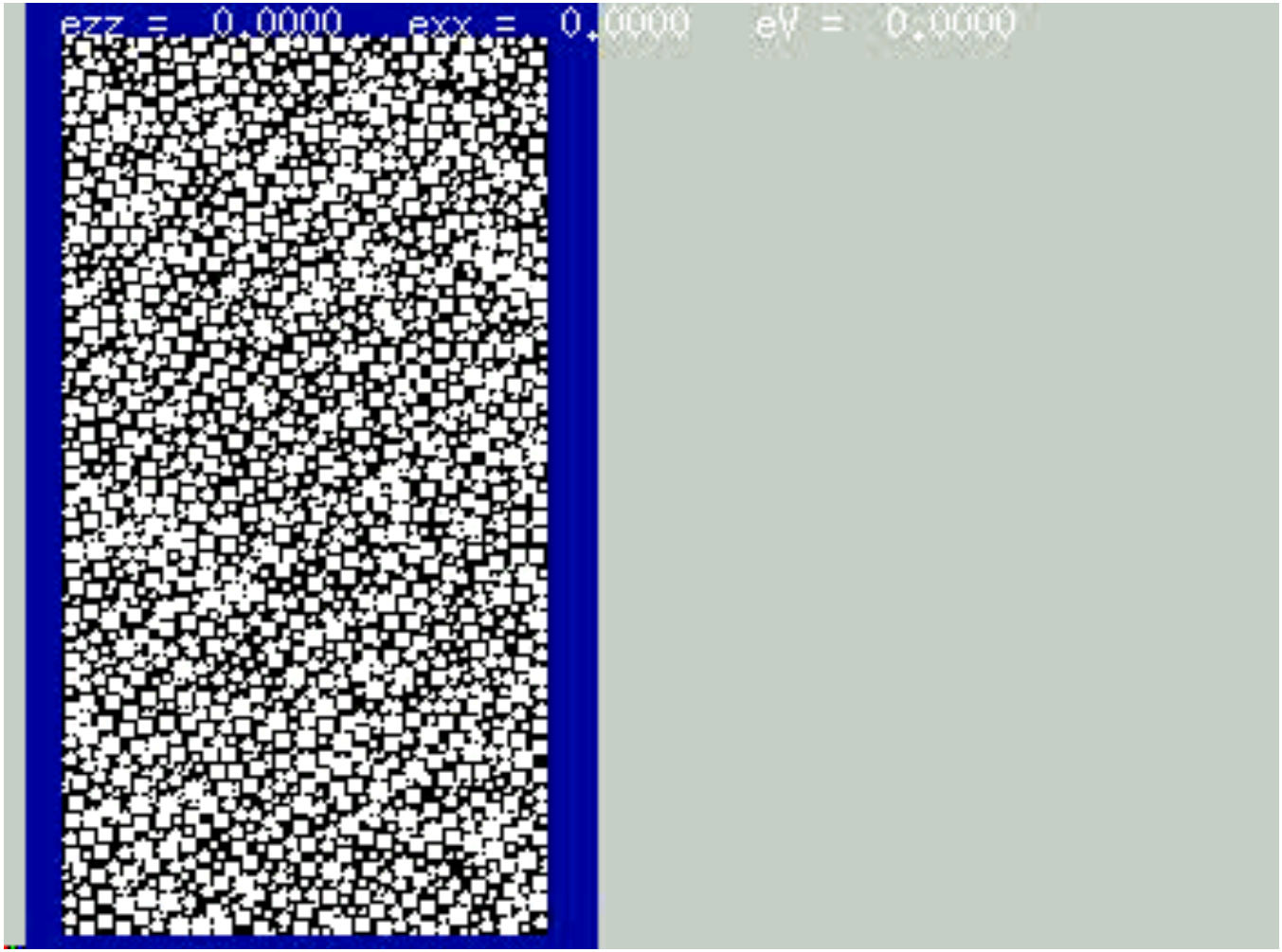
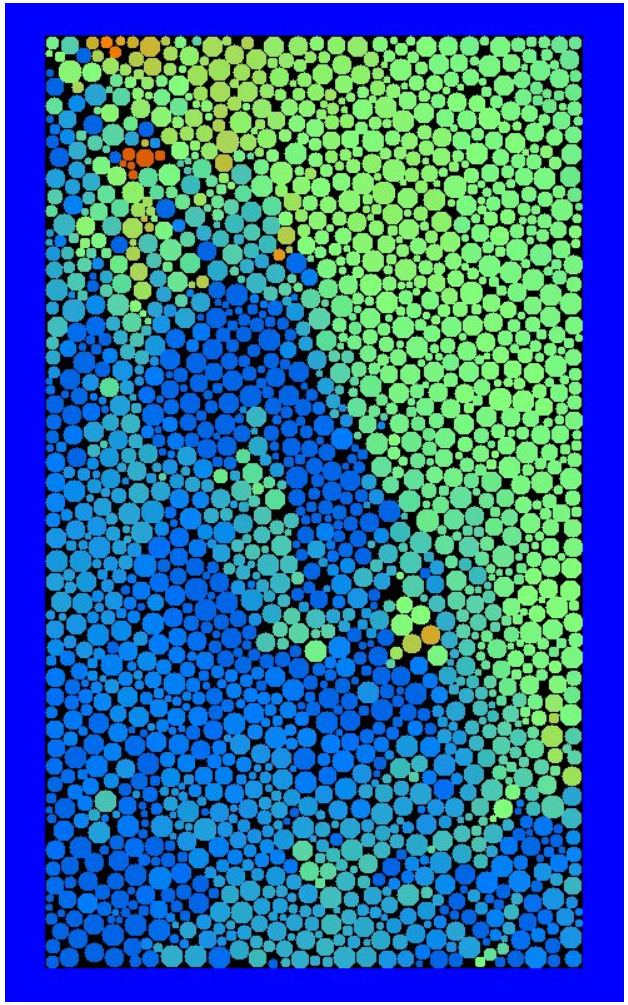


Bi-axial box (kinetic energy)



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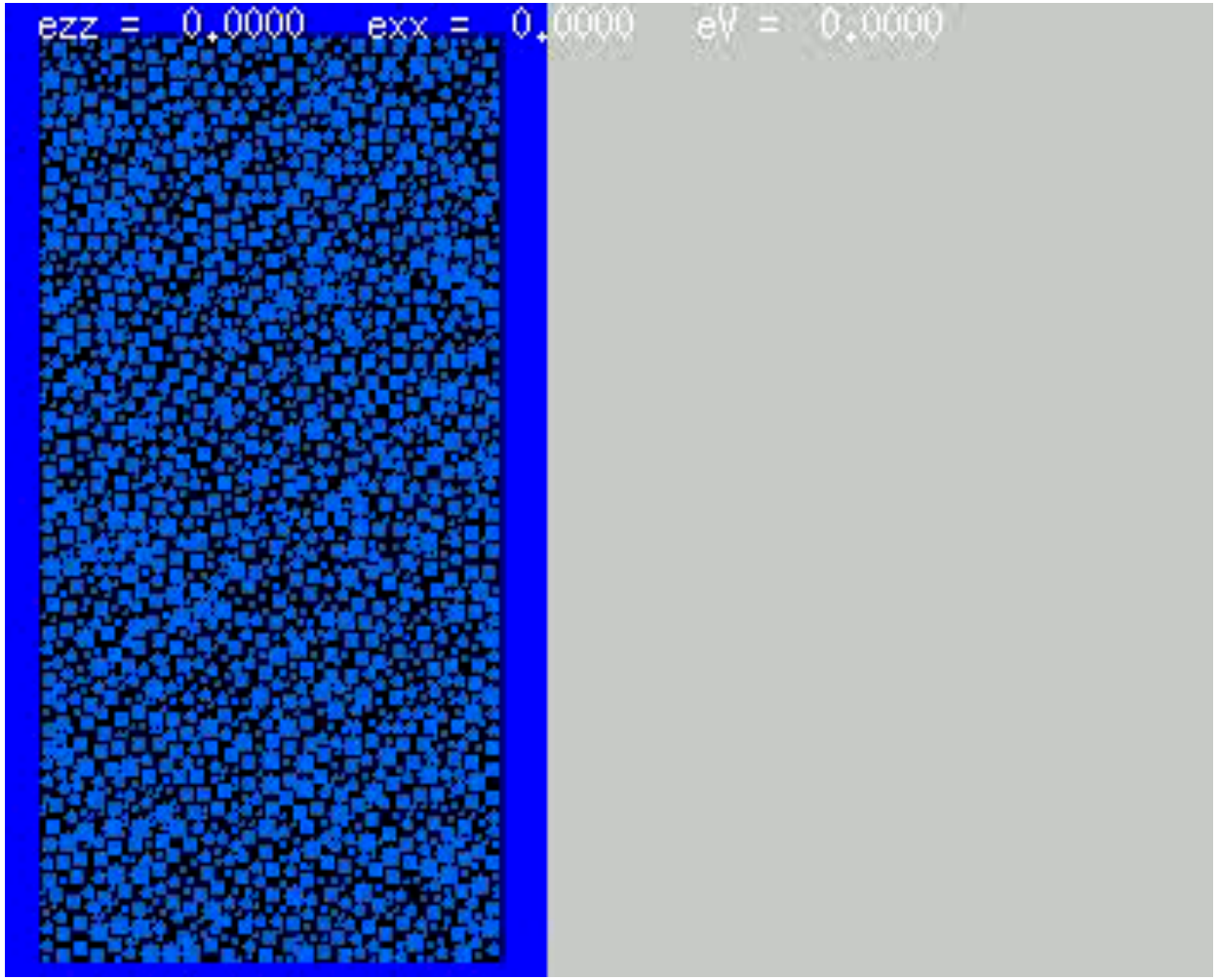
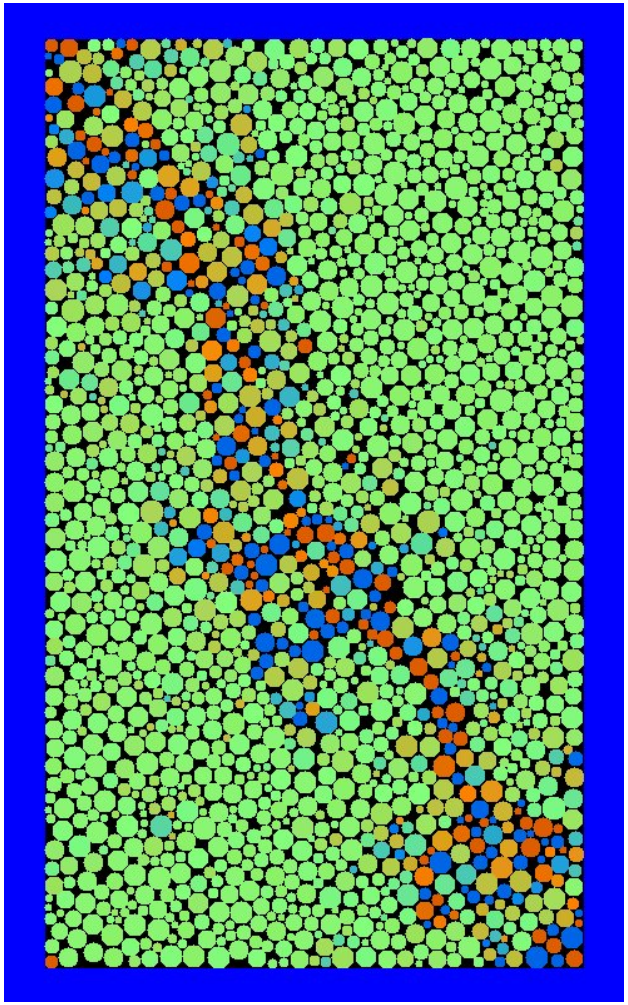


Bi-axial box (rotations)



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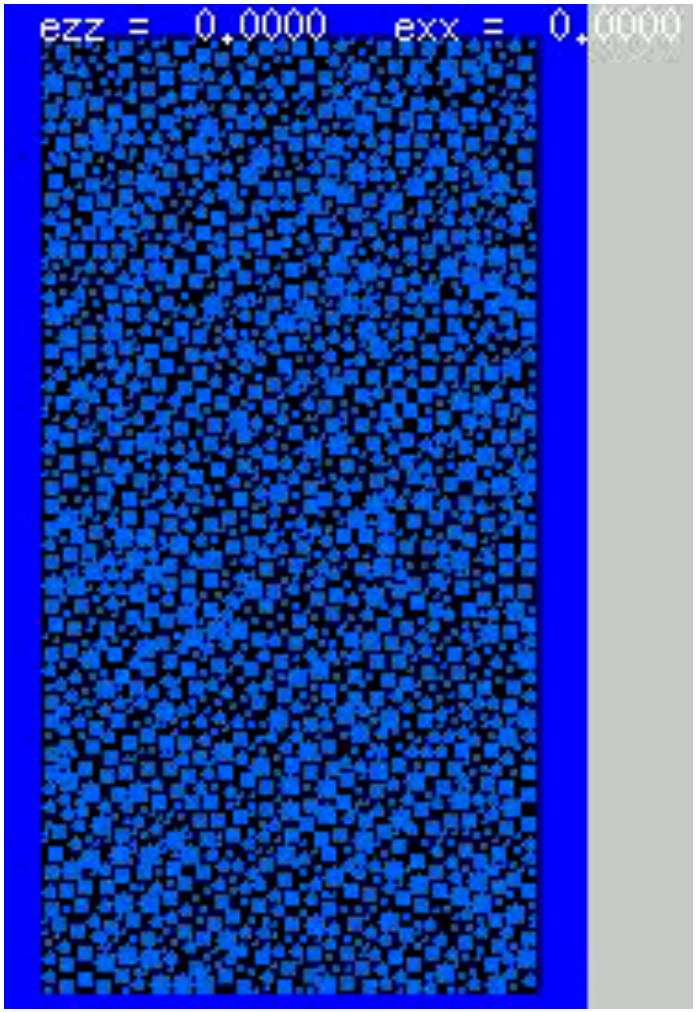
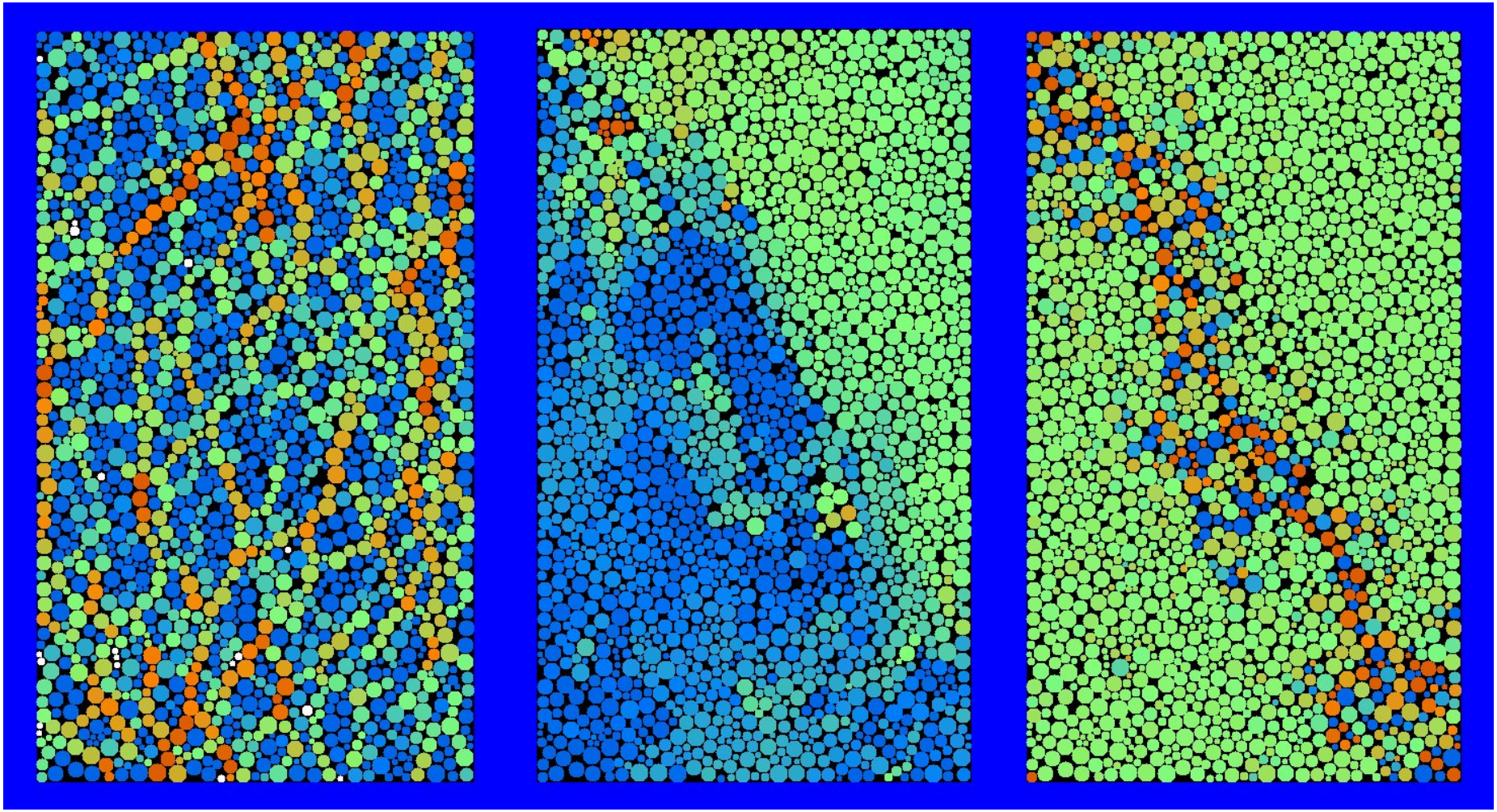


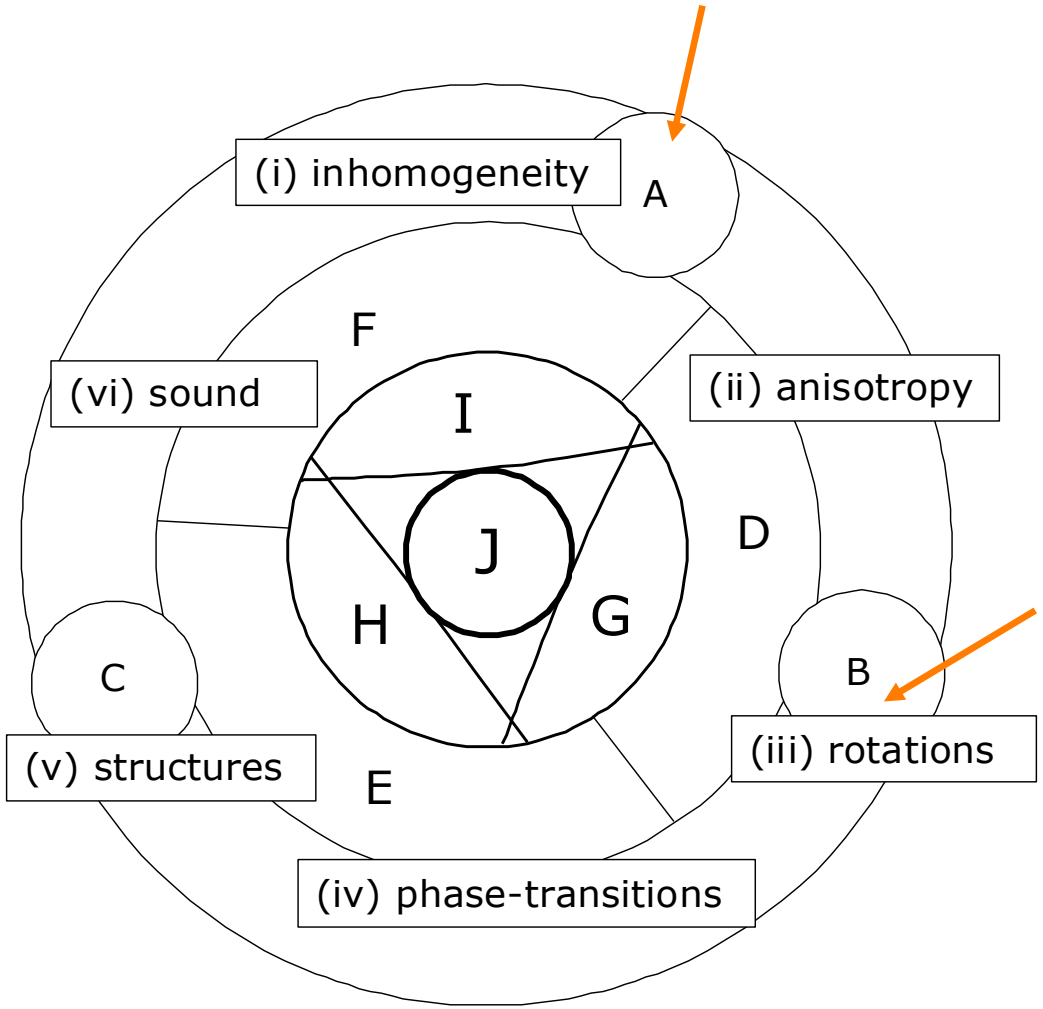
Multiple micro-mechanisms



inhomogeneity & anisotropy, instabilities & structures, rotations

How?

- inhomogeneity
- anisotropy
- rotations



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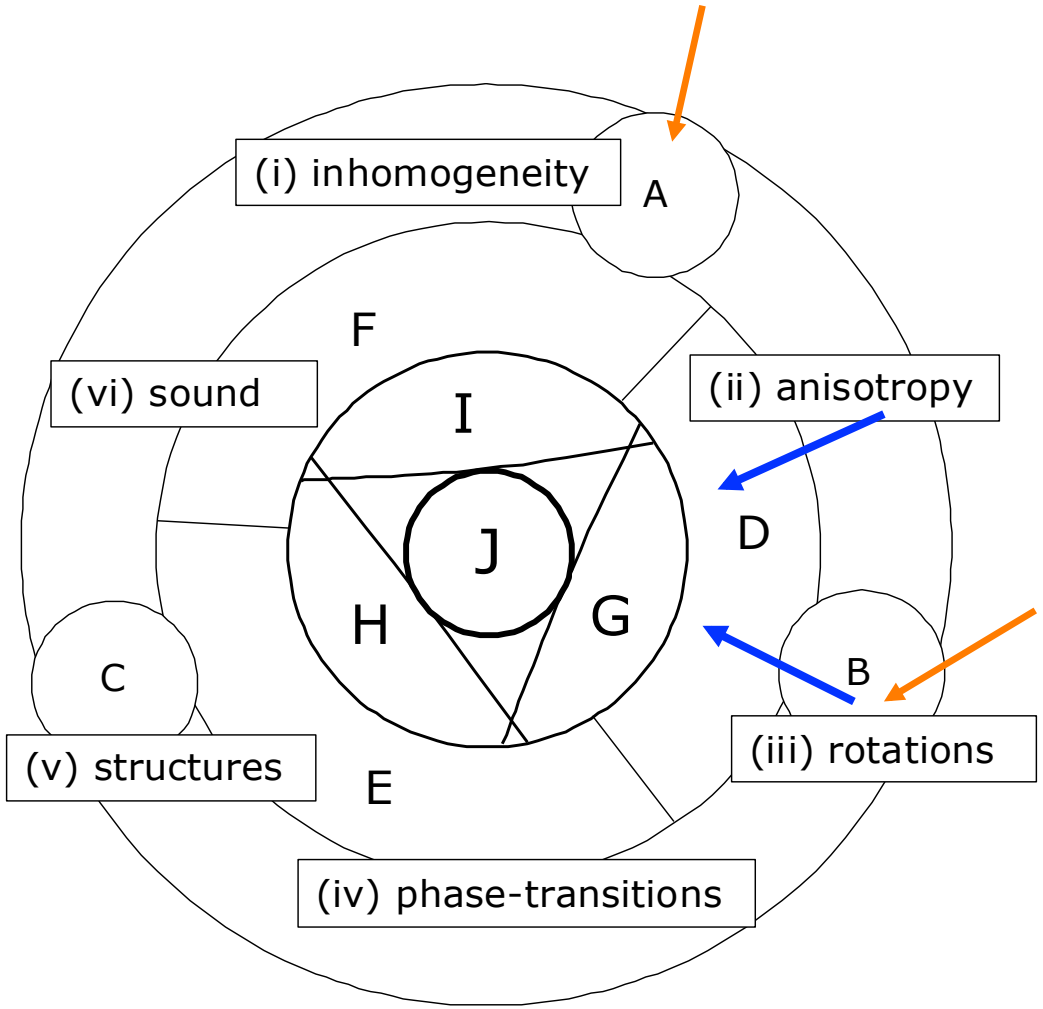

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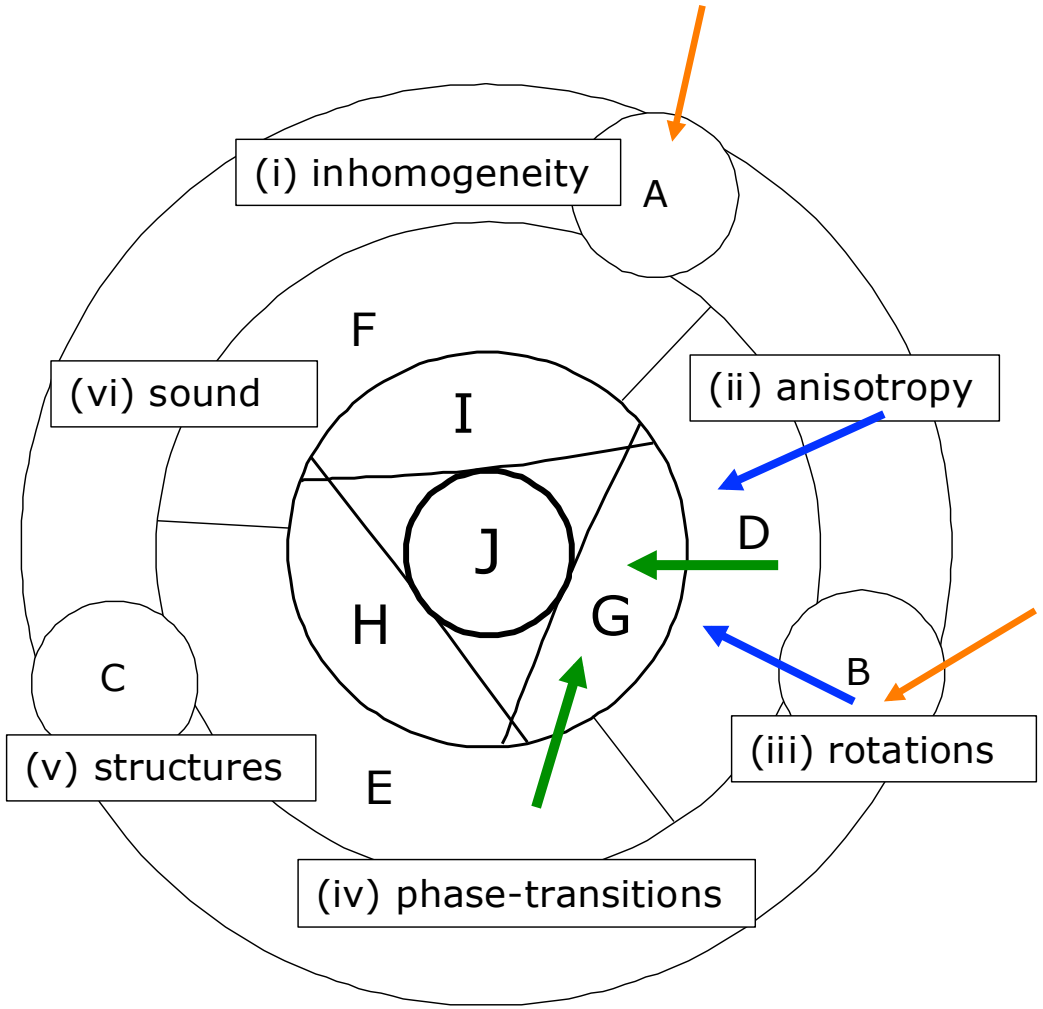

How?

- Particle methods numerics and validation
- Micro-macro methods, combining
  statistical physics and eng. mechanics
- Fluid and Solid Mechanics
- Continuum Theory for Applications

Collaborations?

- Particle methods (MSM) validation (PARDEM)
- Micro-macro methods (FOM, STW)
- Fluid (JMBC) and Solid Mechanics (EM)

  … Continuum Theory (UT-CTW, …)
- Statistical & Exp. Physics (DLR, Duisburg, ETHZ)
- Mechanical and Chemical Engineering (e.g. BASF)
- Food (Nestle) & Pharma Industry (BI-Mainz)

Applications:

- sound-propagation in soils, disordered modern/ bio-materials for non-invasive tests

-clustering-/structure-formation in aerosols and chemical engineering processes

- prediction of instabilities and failure in soils and engineering structures

- material properties and behavior in micro-/nano (fluid&solid) systems

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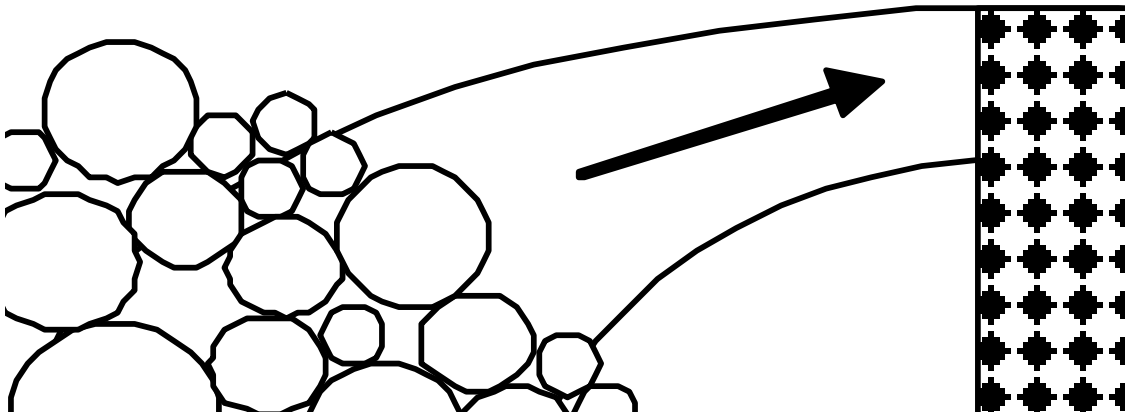
Impact: Avoid energy-loss, improve safety, improve durability, reduce costs



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