10828

Bridging the gap between particulate systems and continuum theory

Stefan Luding, MSM, CTW, MESA+, UTwente, NL

msm

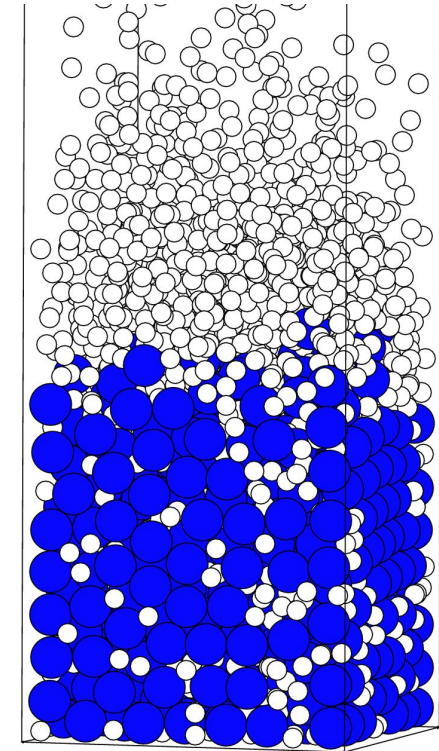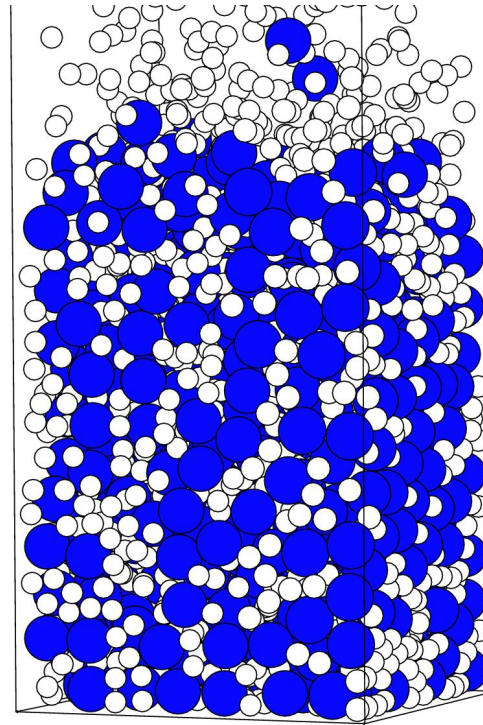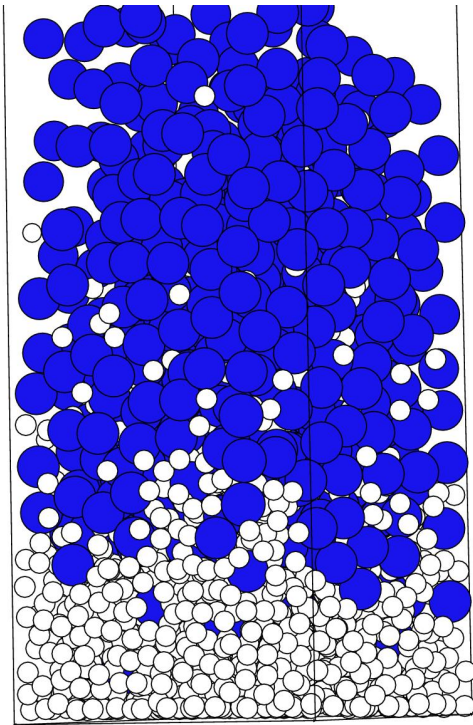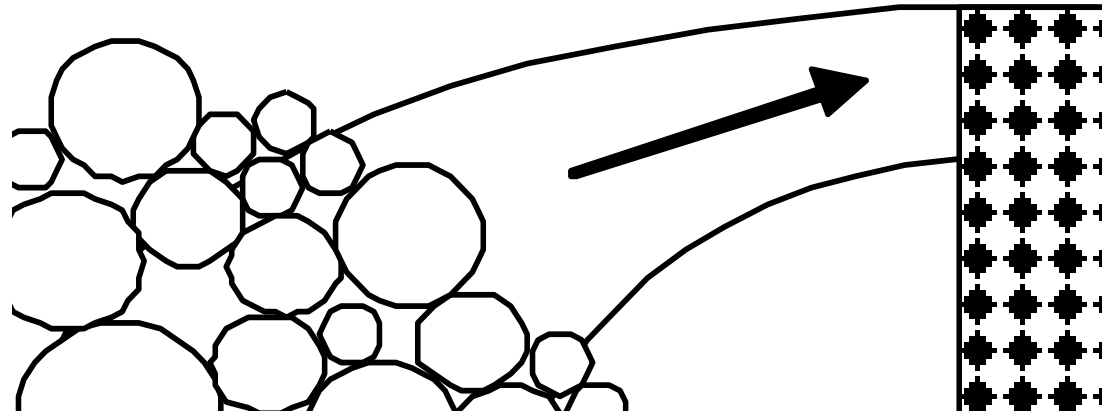soil, sand, powders, concrete, ceramics, cells, blood, ...

particulate systems

msm

Example:　Segregation/Mixing

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

msm

Why?

- Particle Methods (Micro-Details)

- Method: Micro-Macro Transition
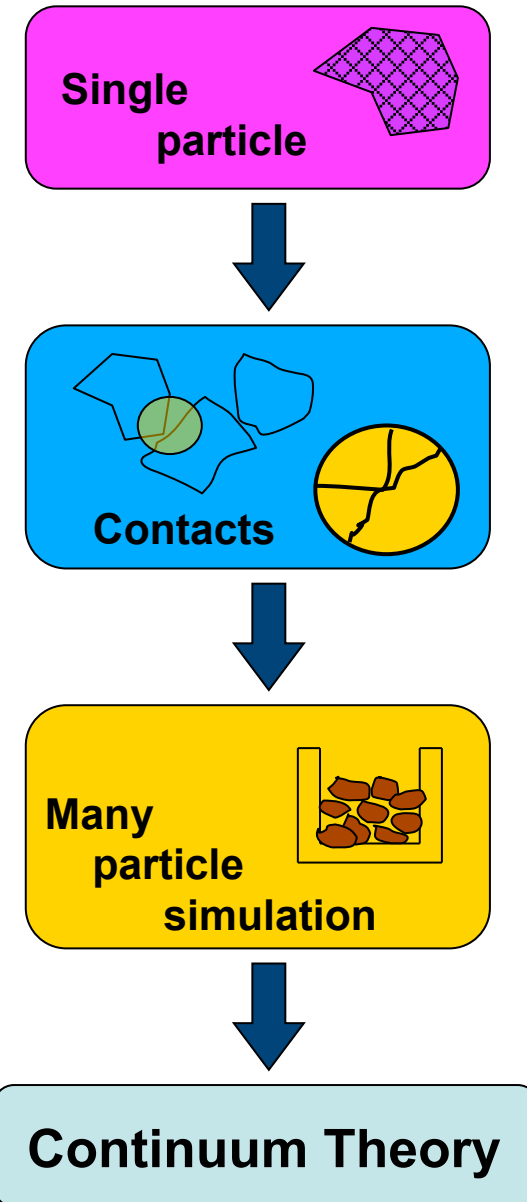
- Continuum Theory (Applications)
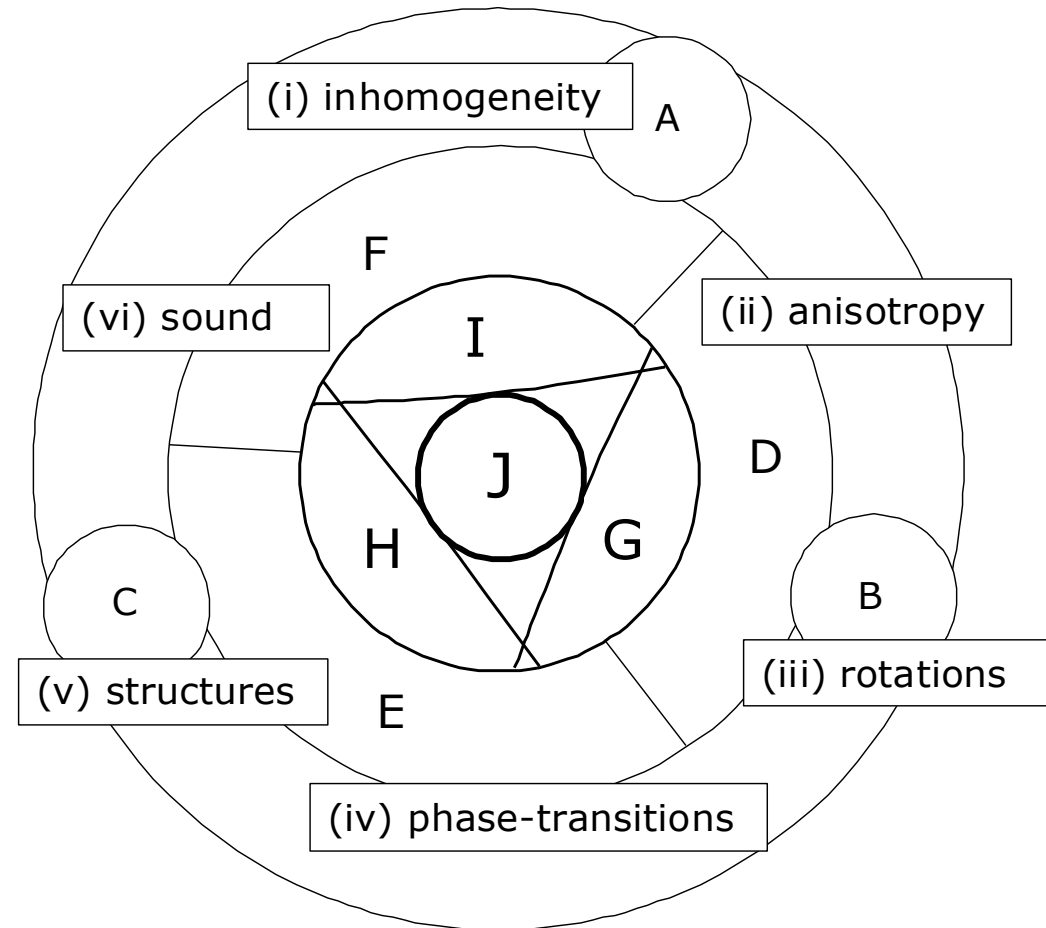

Silo-collapse

Continuum Theory

Approach

- Particle Methods

- Micro-Macro Transition
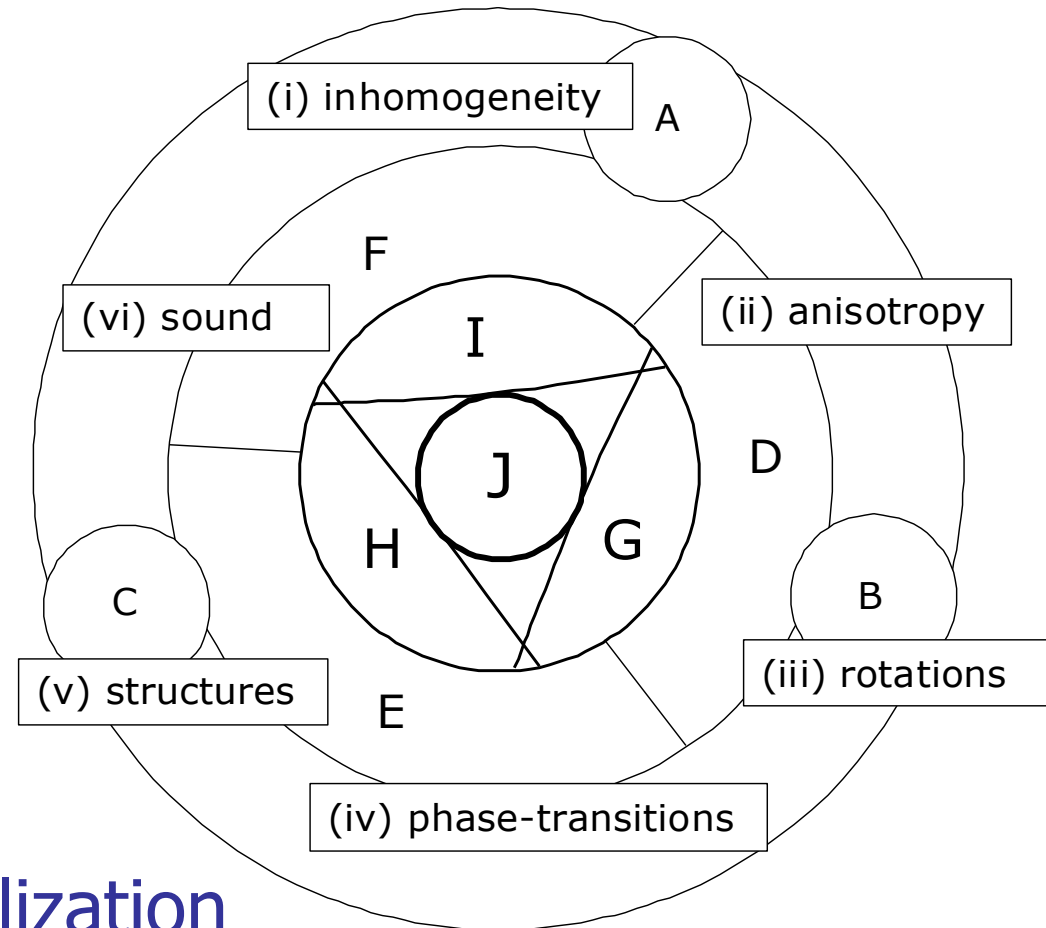
- Towards Continuum Theory

- Applications

Topics …

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

Topics …

- inhomogeneity
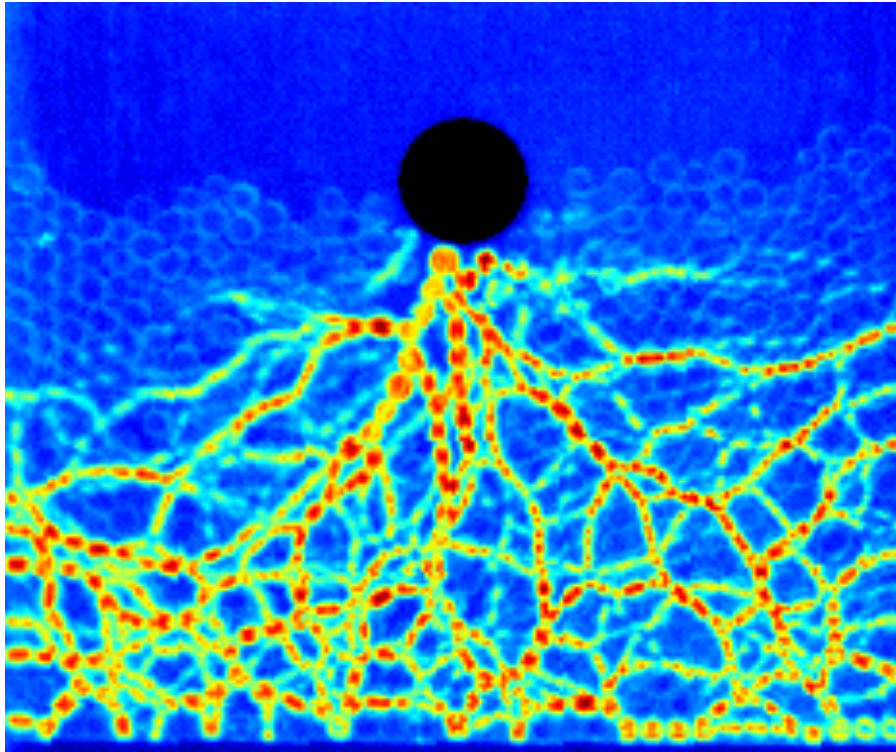- anisotropy
- rotations

Example:
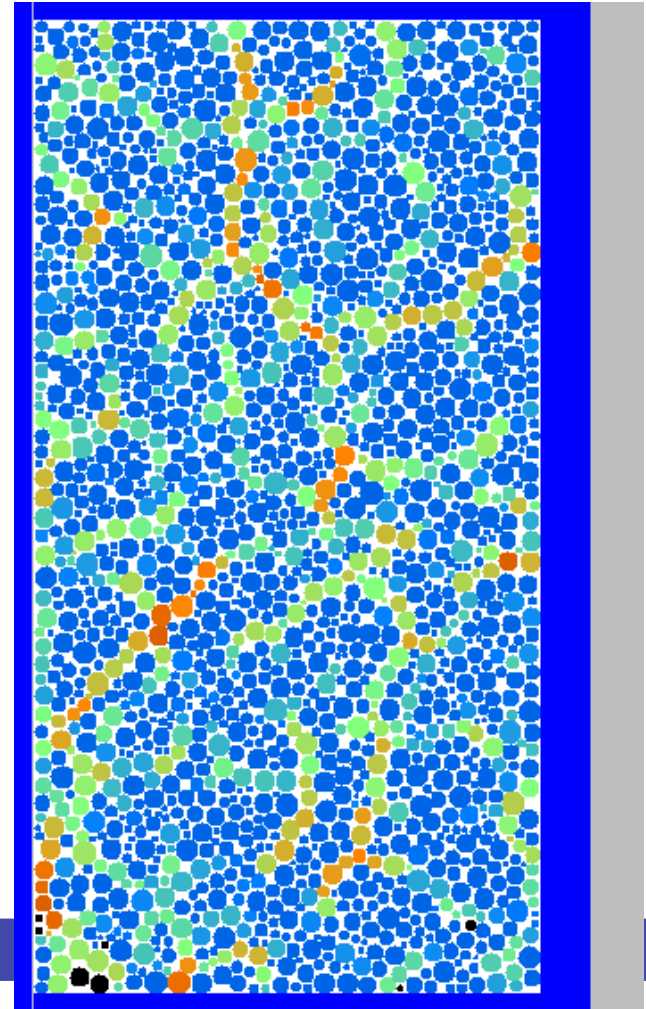 Instability &
 Shear band Localization

Force-chains
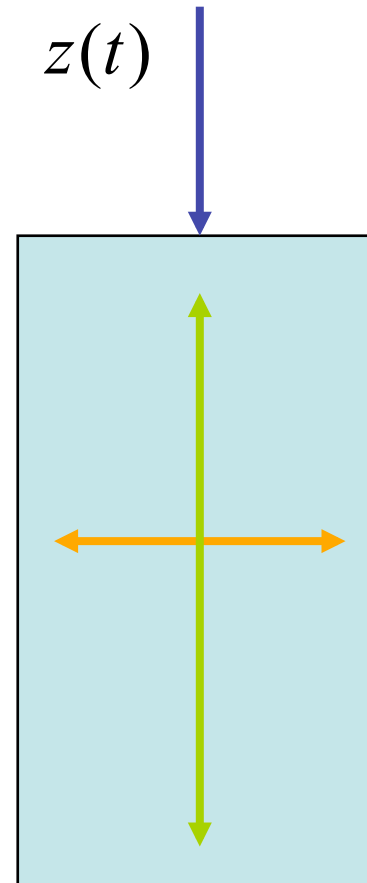## experiments - simulations

2D Exper. Behringer, Duke, USA

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

Biaxial box set-up

- Top wall: strain controlled

- Right wall: stress controlled

$$\sigma_{xx} = \text{const.}$$

$z(t)$

Simulation results (closer look)
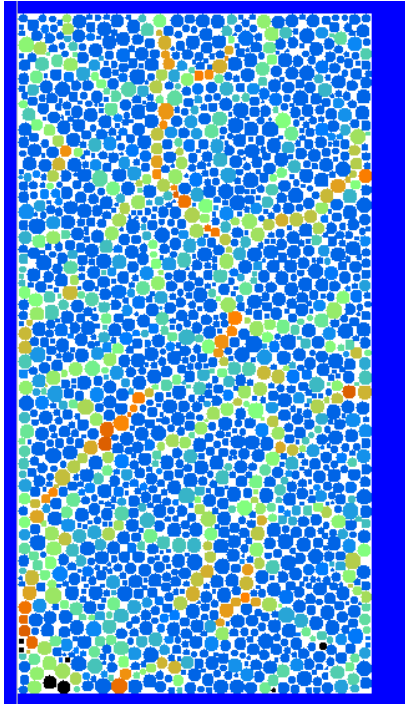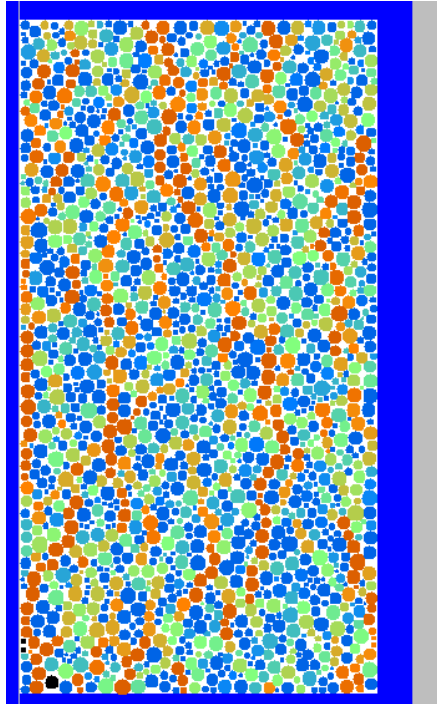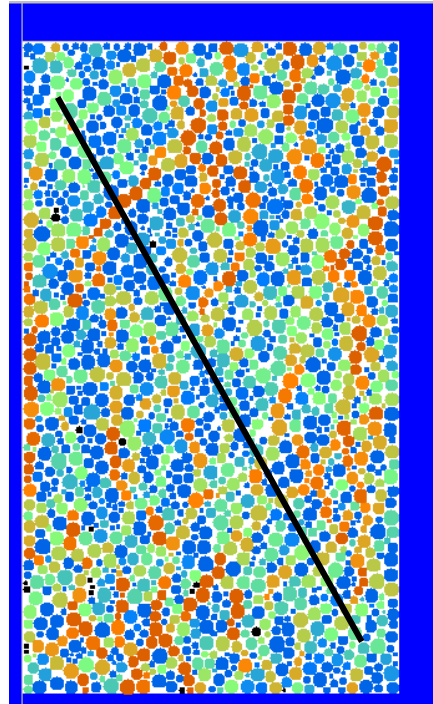
$\varepsilon_{zz}=0.0\%$ $\varepsilon_{zz}=1.1\%$ $\varepsilon_{zz}=4.2\%$ $\varepsilon_{zz}=9.1\%$
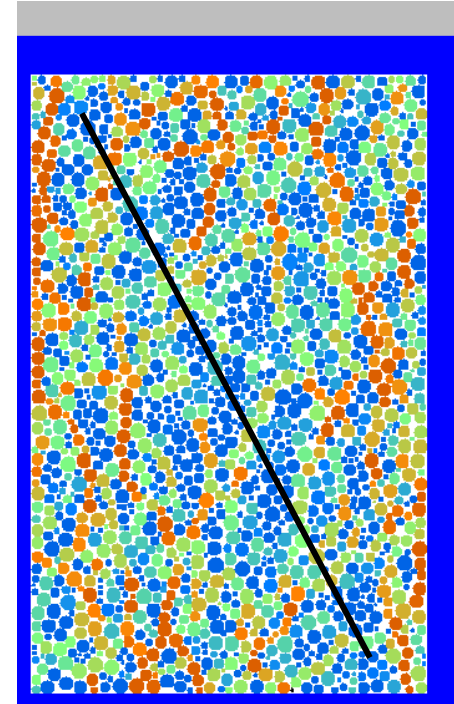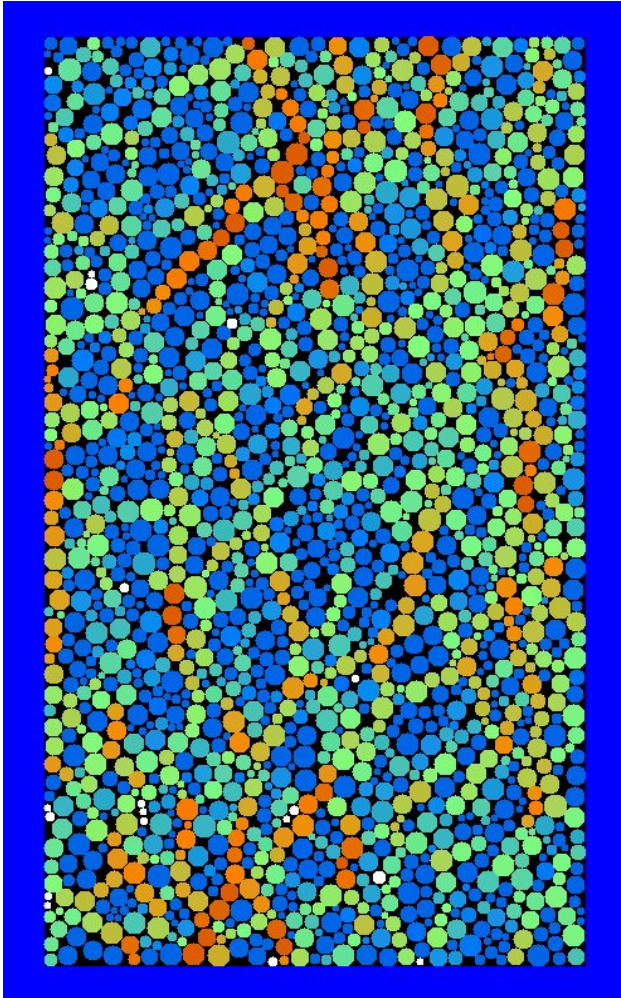
Bi-axial box (stress chains)

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ezz = 0.0000   exx = 0.0000   eV = 0.0000
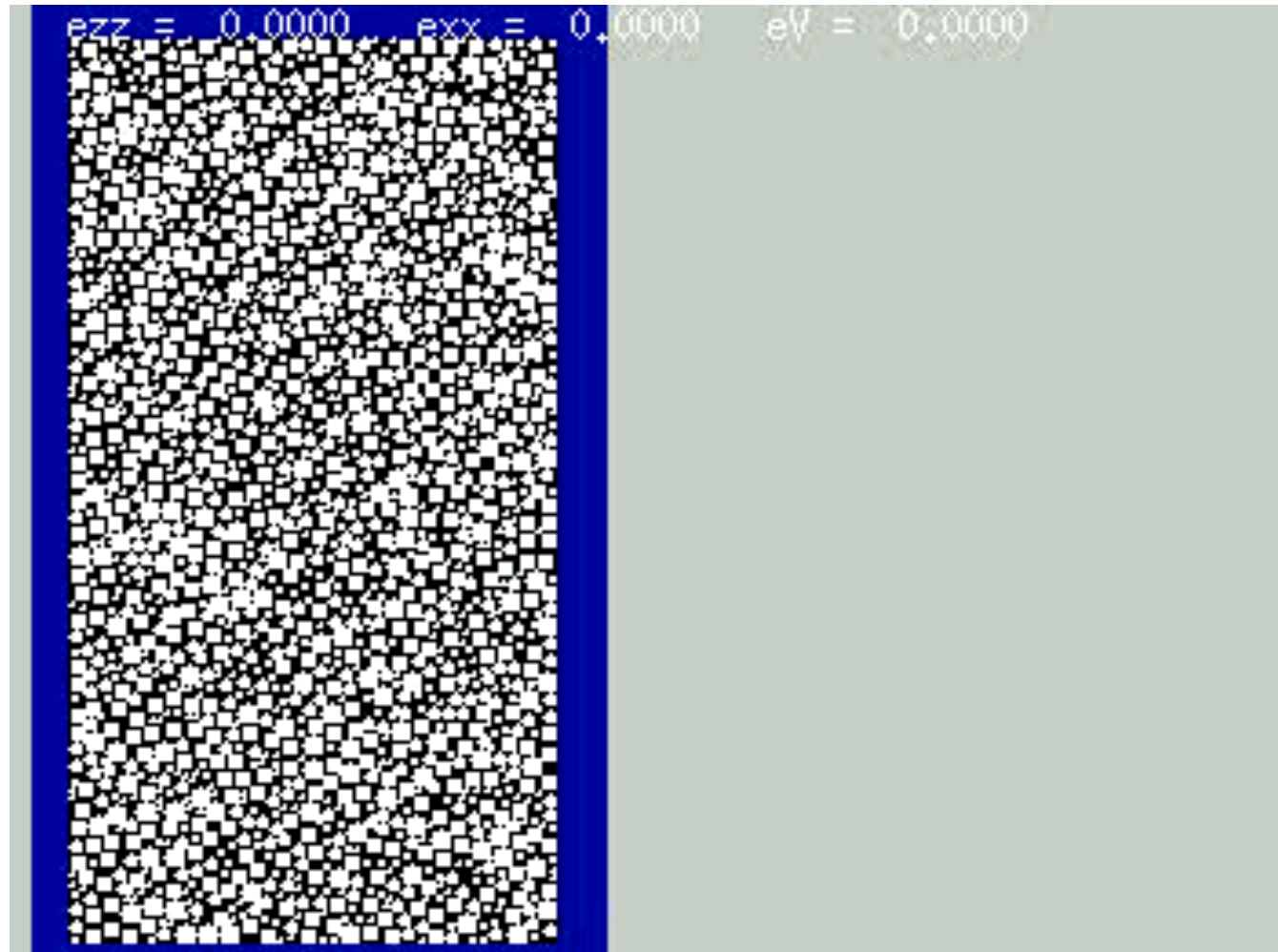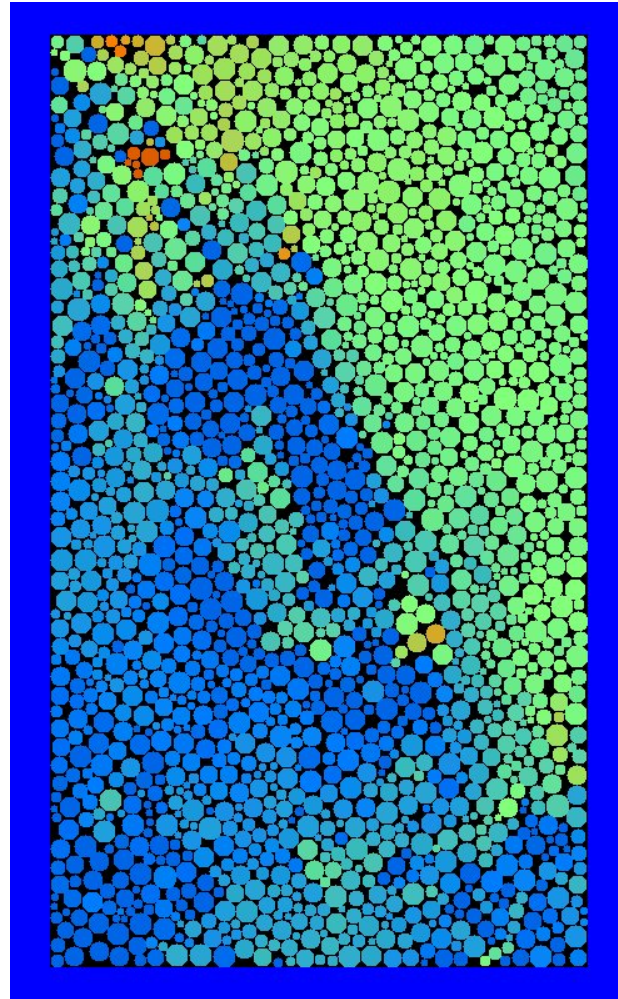
Bi-axial box (kinetic energy)

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ezz = 0.0000   exx = 0.0000   eV = 0.0000
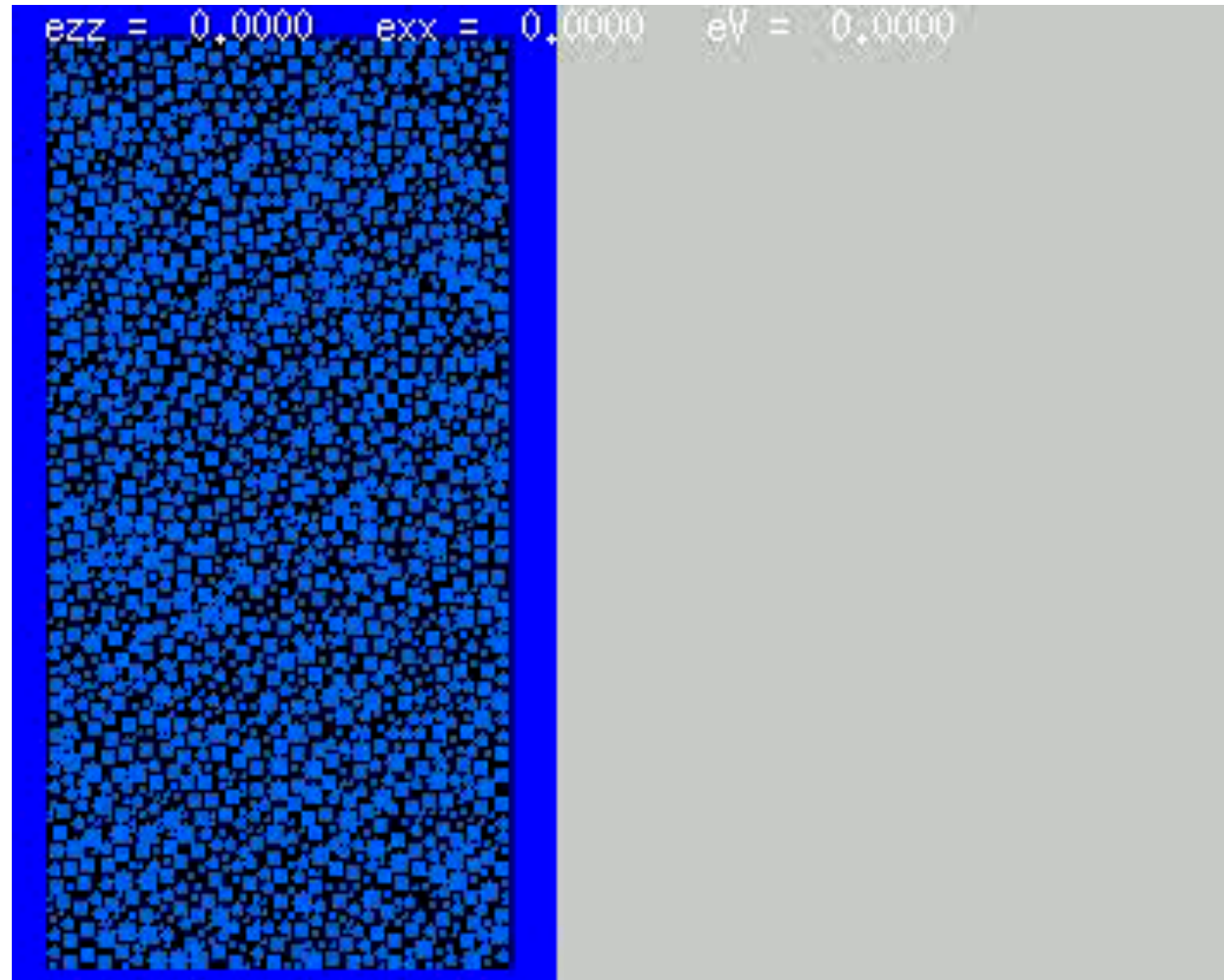
Bi-axial box (rotations)
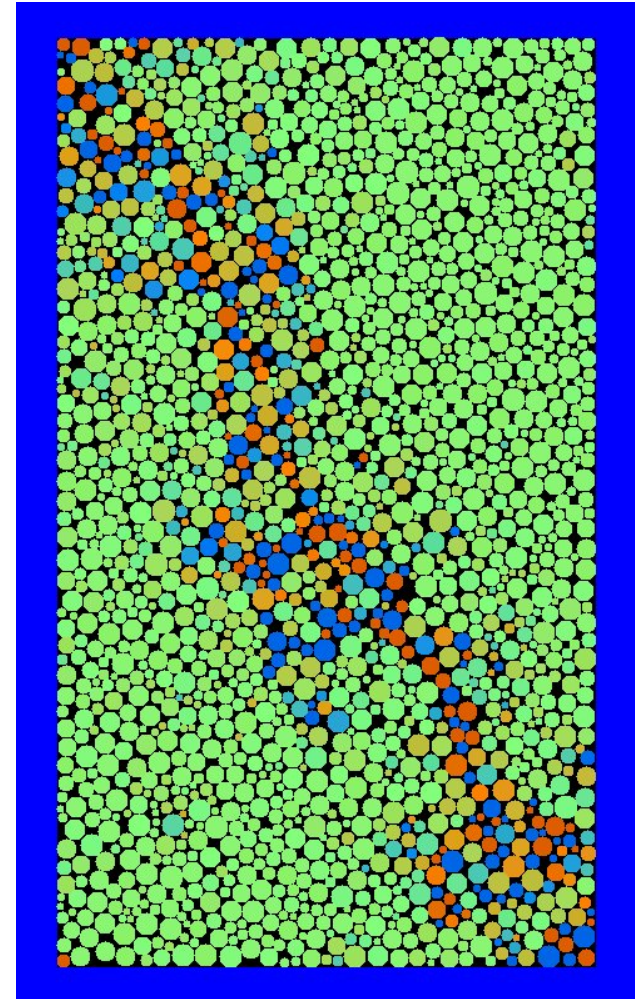
Bi-axial box (rotations)
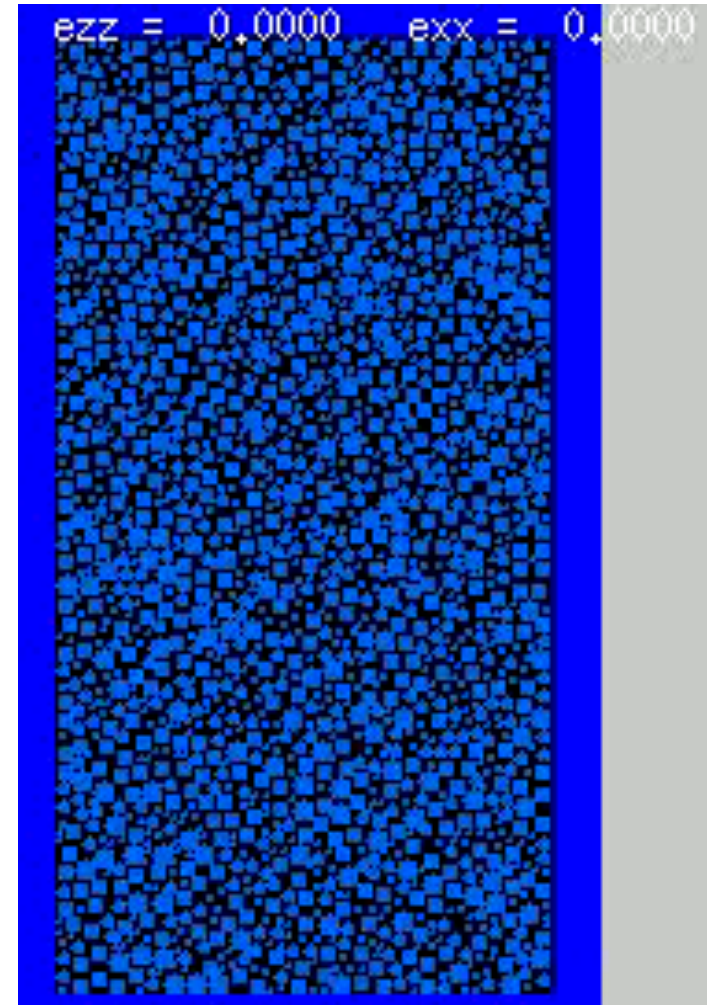
Multiple micro-mechanisms
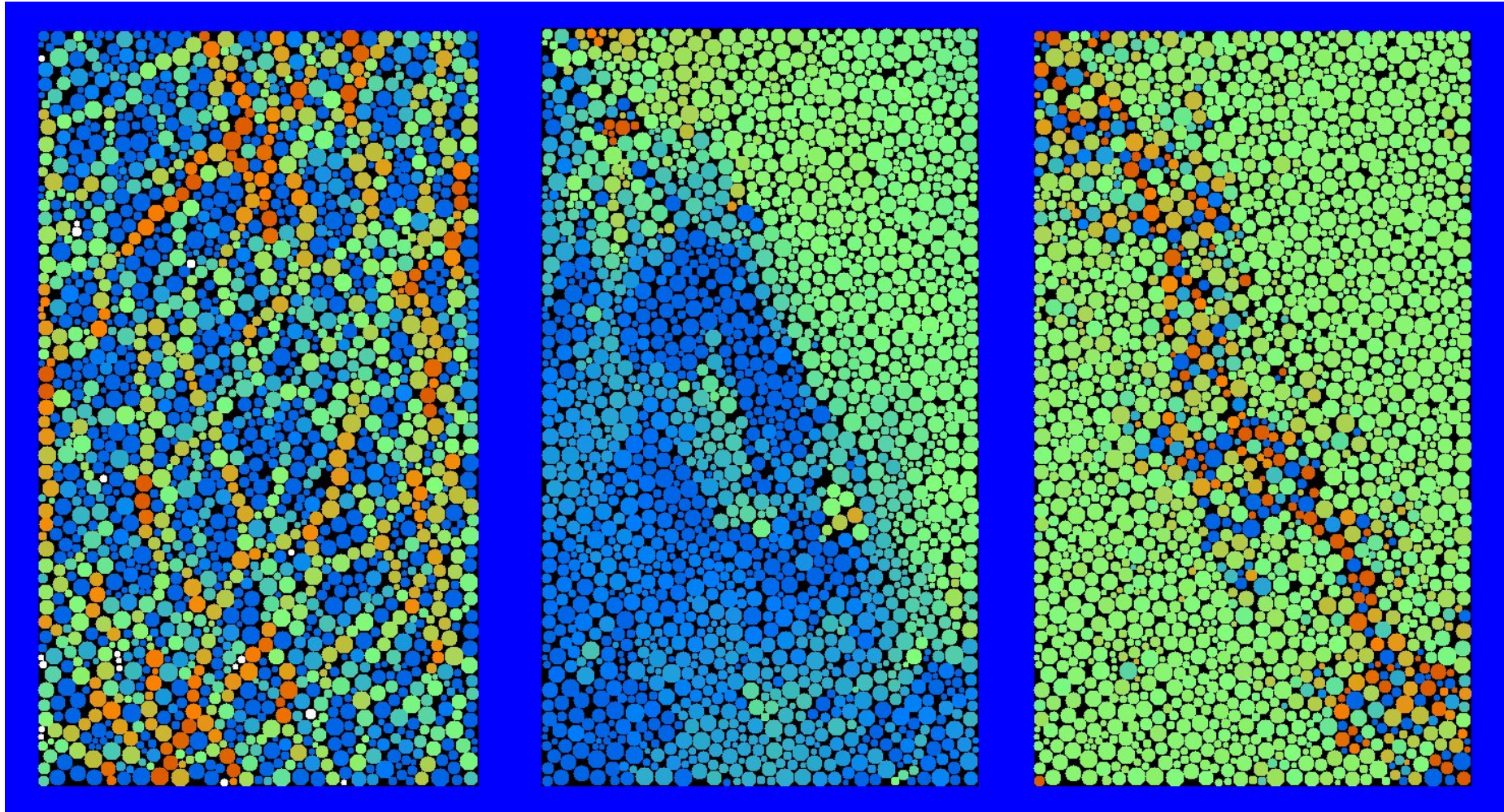
inhomogeneity & anisotropy, instabilities & structures, rotations

How?

- inhomogeneity
- anisotropy
- rotations

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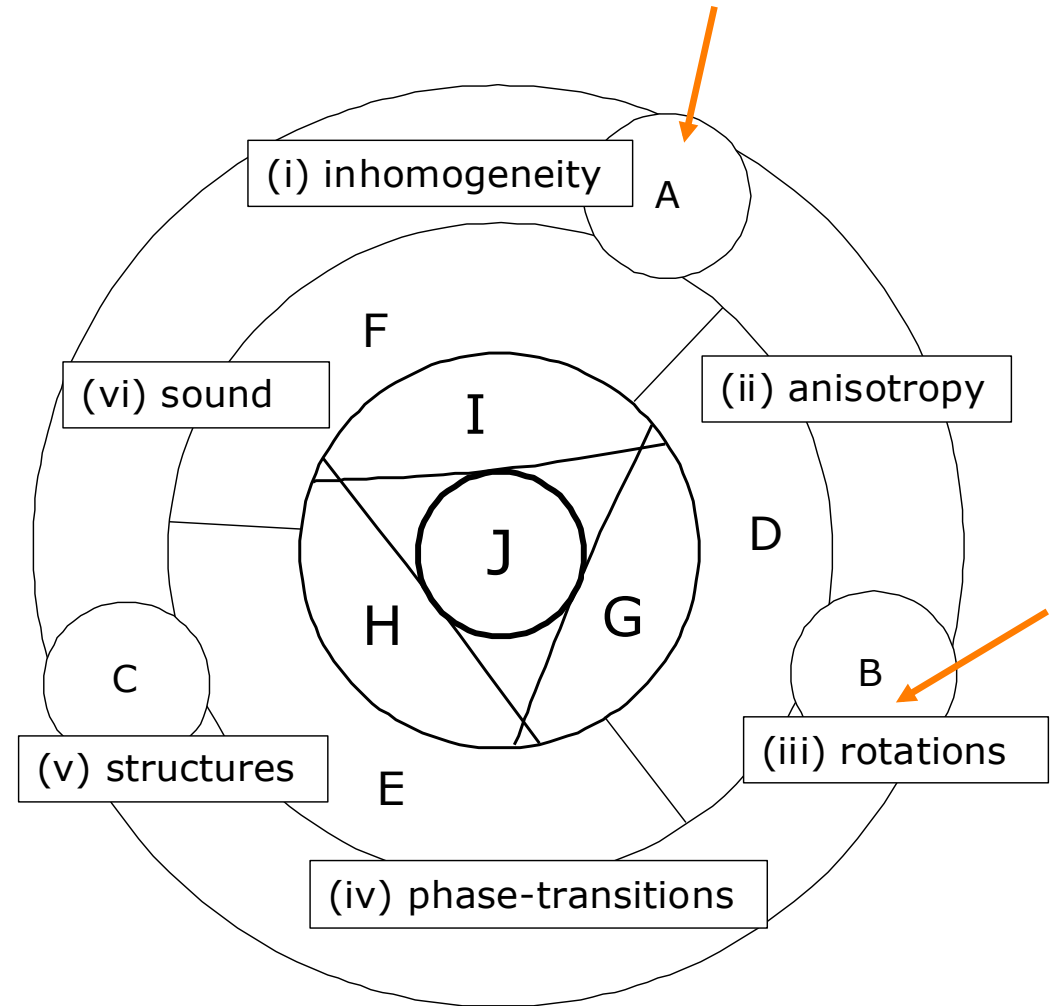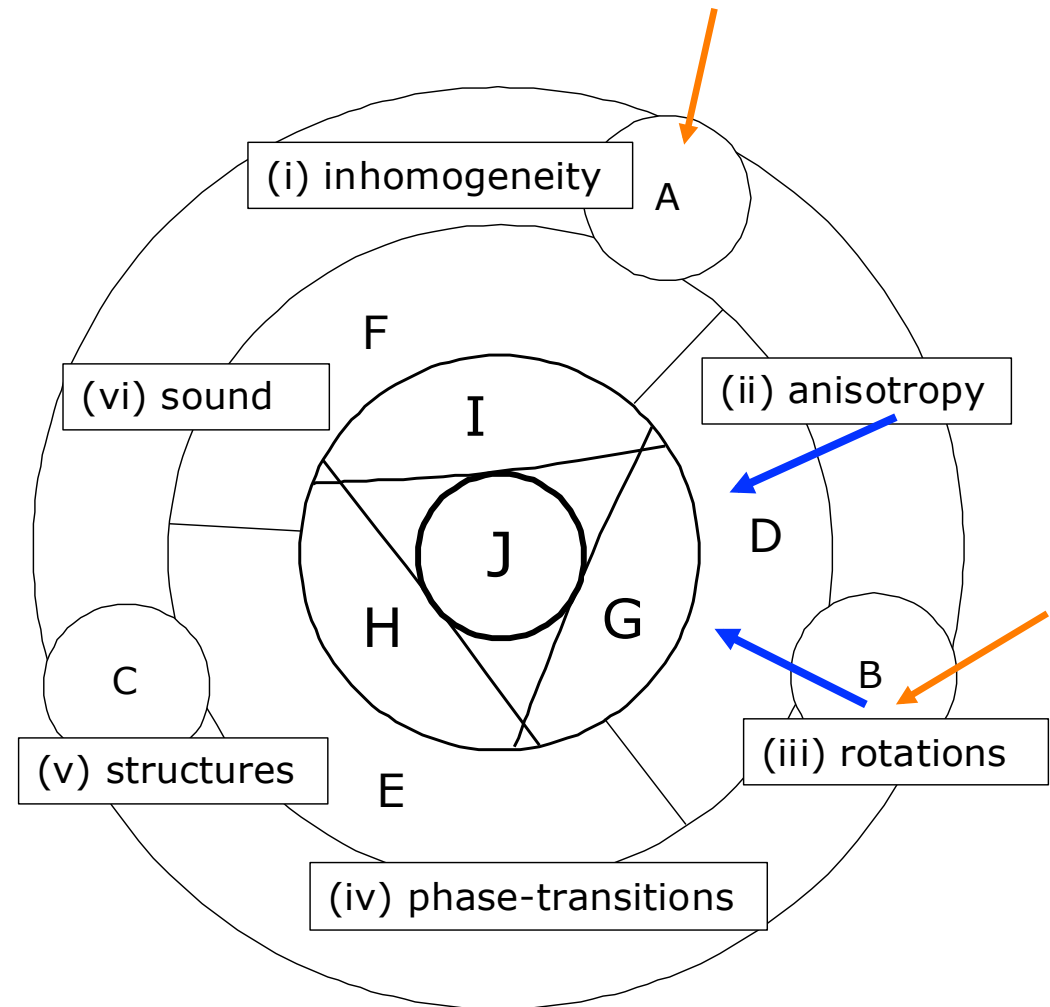
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- anisotropy
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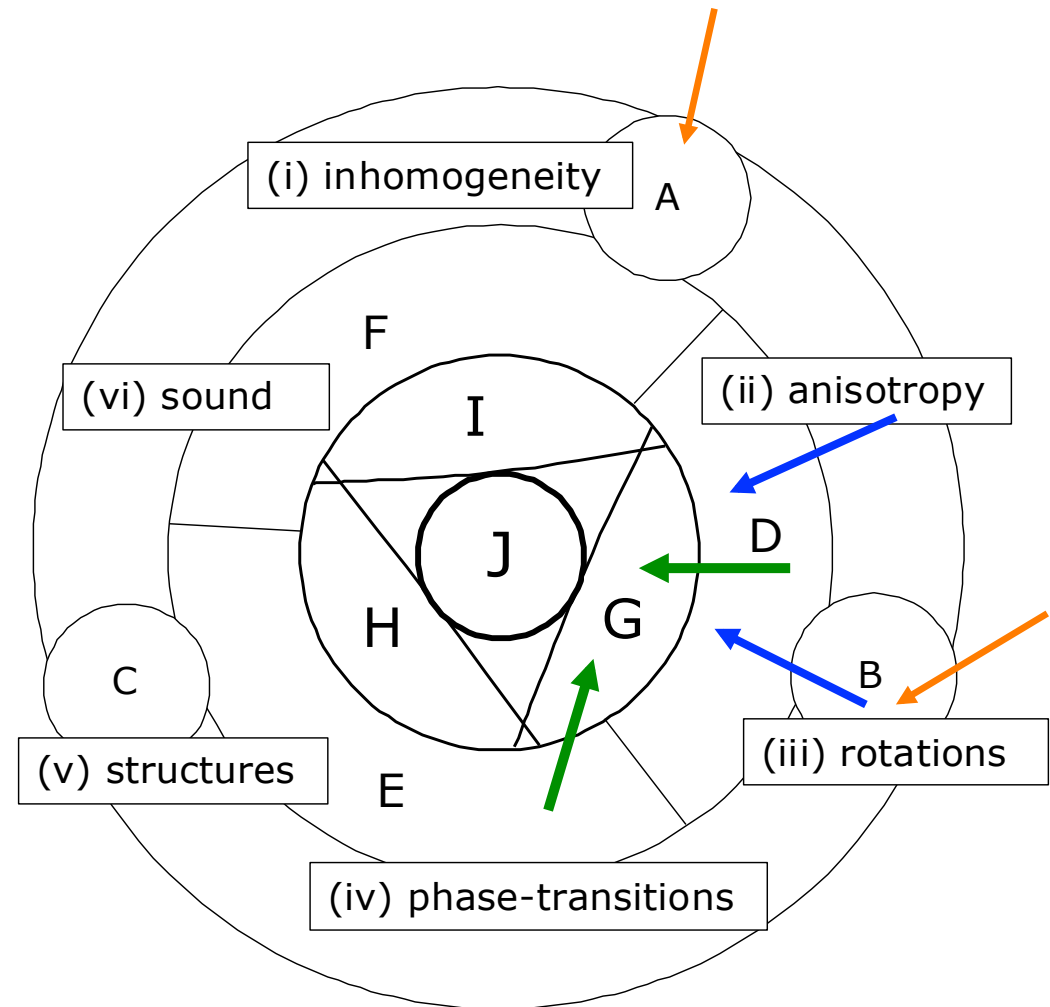
Themes worked on?

- inhomogeneity
- anisotropy
- rotations
- phase-transitions
- structures
- sound
- mixing
- …
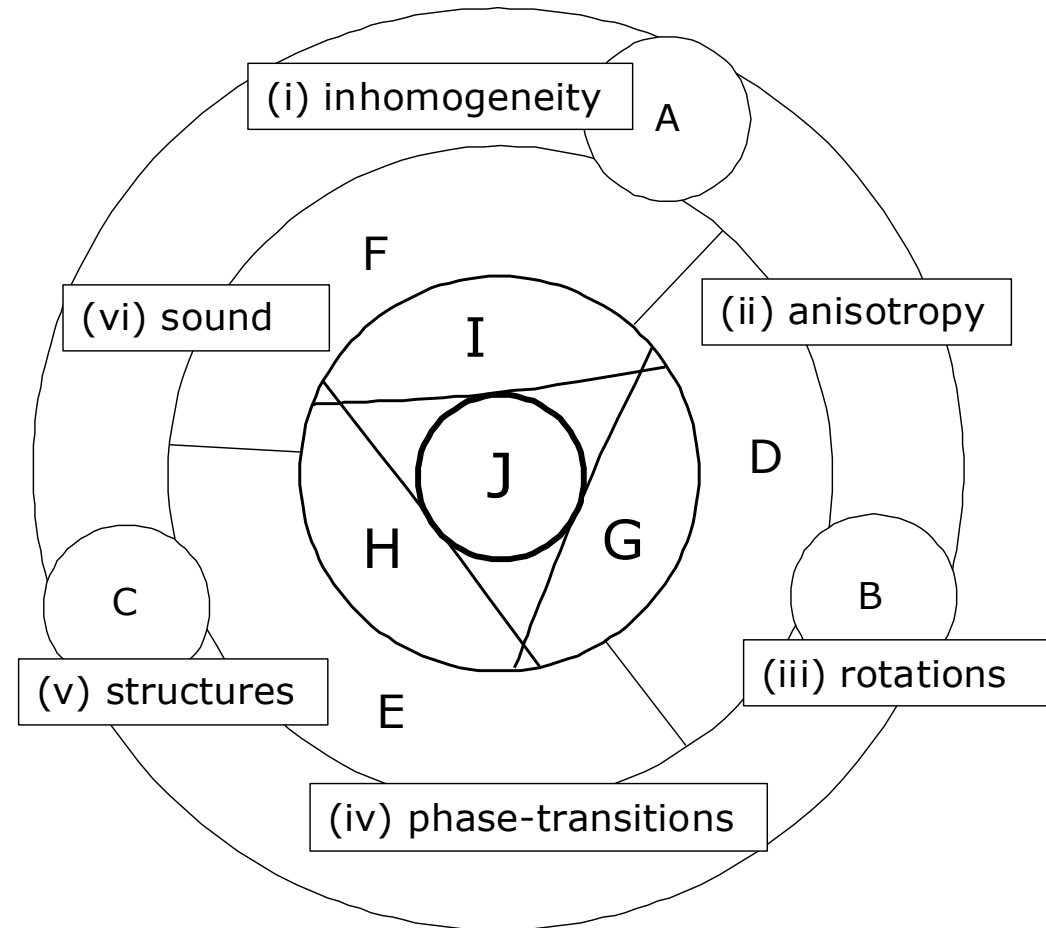
Themes worked on?

- inhomogeneity, non-affine motion, master-pdf(force)
- anisotropy continuum model
- rotations (contact+particle => continuum)
- phase-transitions (fluid-solid, jamming)
- structures (micro+macro, analysis => prediction)
- sound/waves
- mixing/polydispersity/multiscale
- ...

Overview – who and what?

- inhomogeneity (A. Singh, K. Saitoh, N. Rivas)
- anisotropy (T. Weinhart, D. Krijgsman,
           R. Hartkamp, A. Singh)
- rotations (A. Merkel, T. Weinhart, V. Magnanimo)
- phase-transitions/jamming: (N. Rivas, K. Saitoh,
           T. Weinhart, N. Kumar (PARDEM))
- structures (micro: A. Singh, macro: N. Rivas)
- sound (B. Lawney, A. Merkel, V. Magnanimo,
         MSc: L. de Mol, S. Emmerich, S. Sterl, …)
- mixtures (N. Rivas, D. Krijgsman, T. Weinhart,
           A. Thornton, D. Tunuguntla (STW), …)
- …

How?

- <u>Particle methods</u> numerics and validation

- <u>Micro-macro methods</u>, combining
  statistical physics and mechanics

- Fluid <u>and</u> Solid Mechanics

- <u>Continuum Theory</u> 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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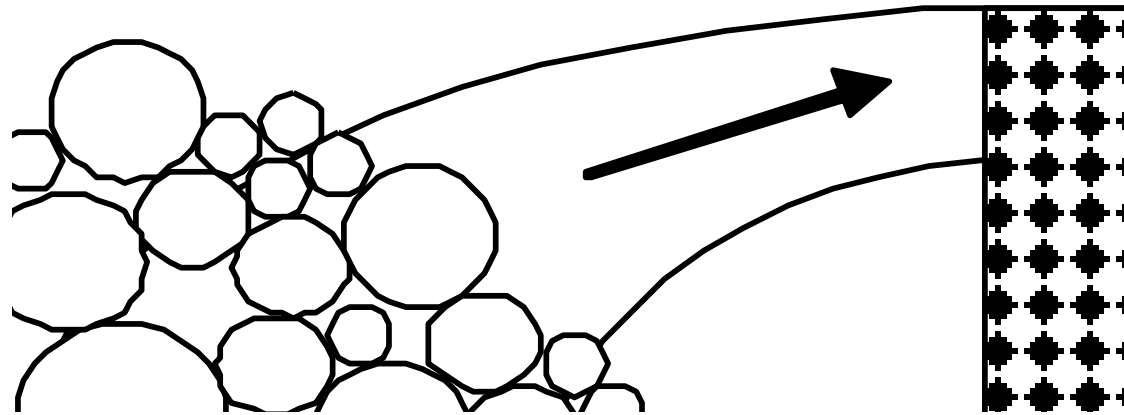   micro-/nano (fluid&solid) systems

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

Program:

13:30-13:35	S. Luding, Opening: "*Bridging the gap between discrete and continuum models*",
13:35-13:50	K. Saitoh: "*Stochastic approach to the PDFs of forces*",
13:50-14:05	N. Rivas: "*Particle size scaling in vertically vibrated granular media*",
14:05-14:20	D. Krijgsman: "*Optimal parameters for contact detection using a hierarchical grid data structure*"
14:20-14:35	T. Weinhart: "*From discrete particles to continuum fields in mixtures*"
14:35-14:50	A. Singh: "*Does gravity have an effect on the slow shear rheology of granular material?*",
14:50-16:00	**Coffee break -> UC Meeting**
16:00-17:00	M. Sperl: "*The Glass Transition in Granular Matter*"
17:00-18:00	L. Silbert: "*Static and Dynamic Perturbations in Granular Materials*",

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and continuum theory
towards macroscopic applications