Granular Dynamics at the Mesoscale

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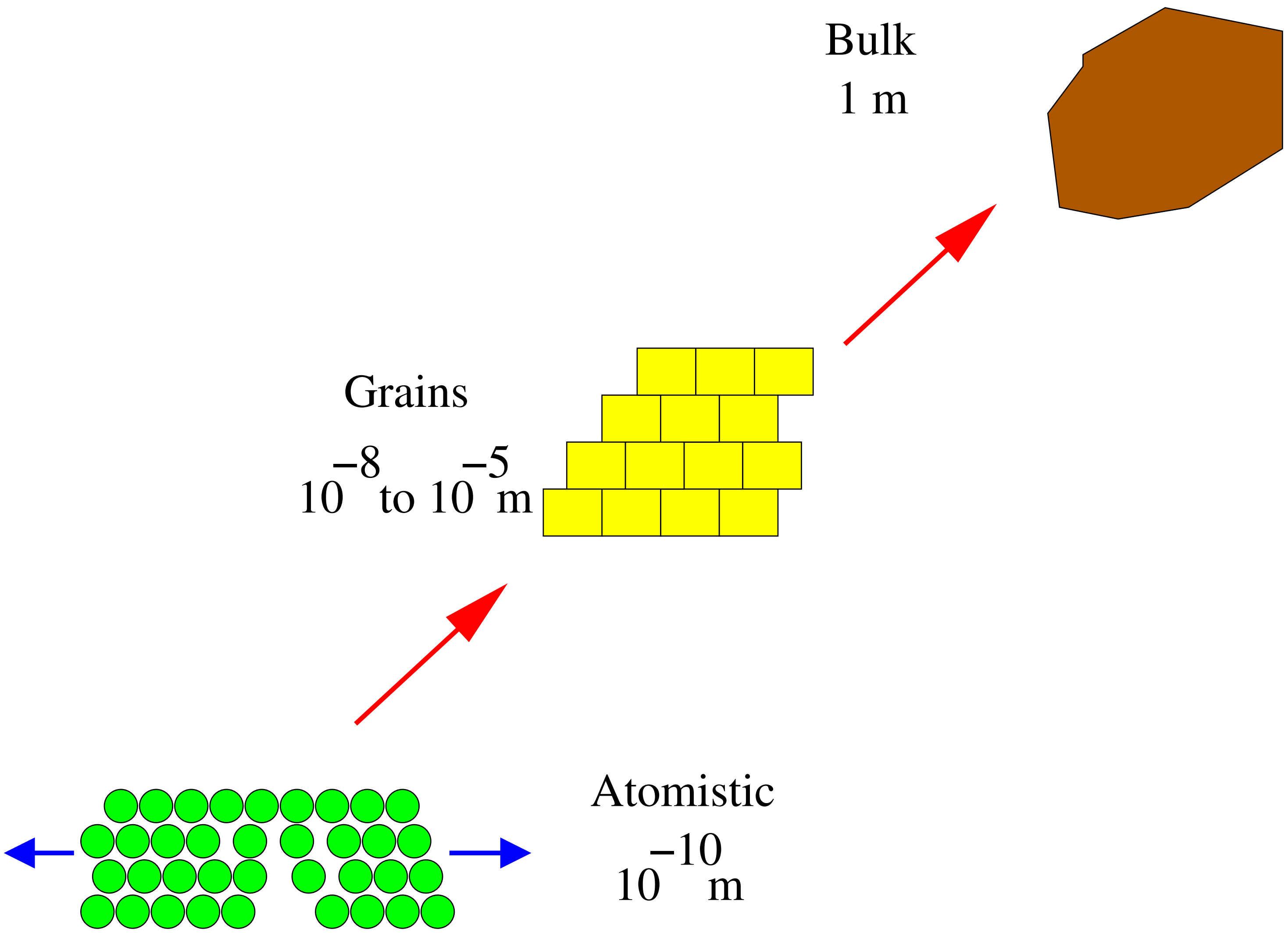
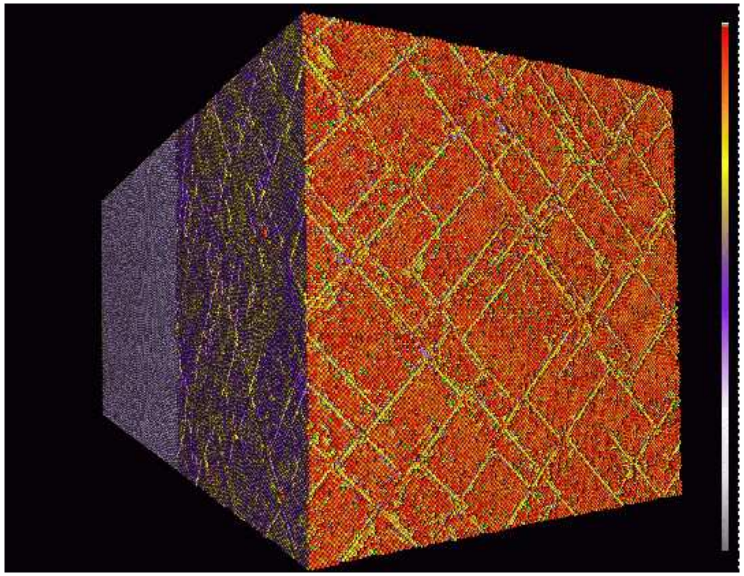
Overview

- Particle-based approach to the mesoscale modeling problem
- Anisotropic grains (monomers, dimers, trimers)
- Simulation details
- Order of granular packing tuned by anisotropy
- Transport of grains over a ratchet base
- Granular chains
- Future Direction and Summary

Multiscale Modeling



Two approaches



Bottom-up (atomistic, 25×10^6 atoms). B.L. Holian and P.S. Lomdahl, Science **280**, 2085 (1998).

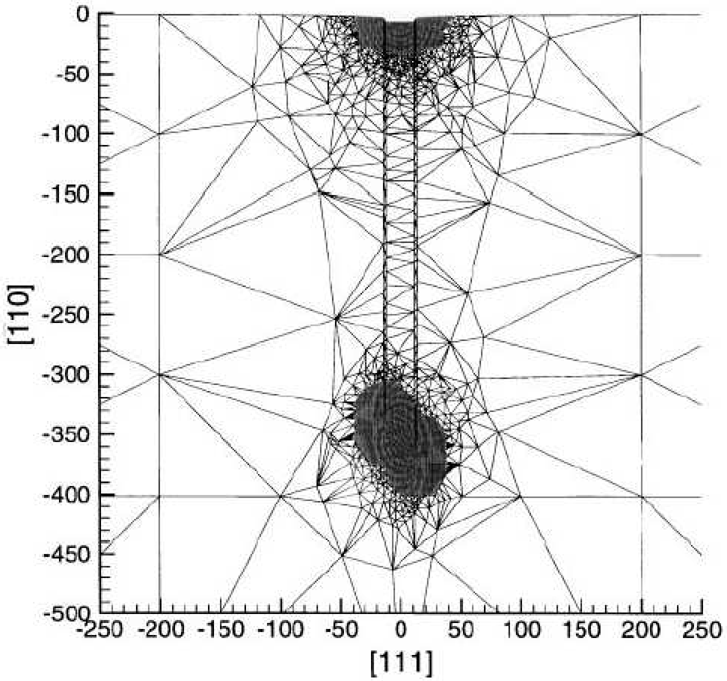
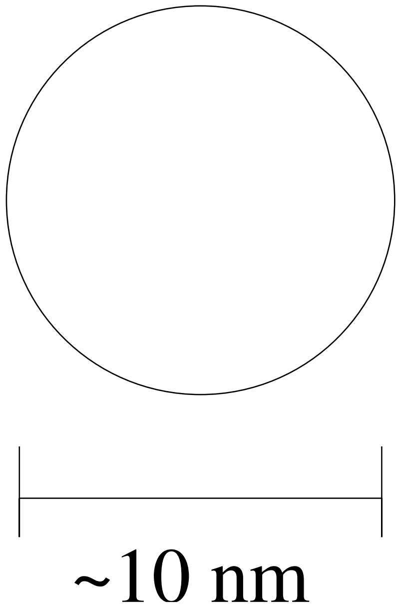
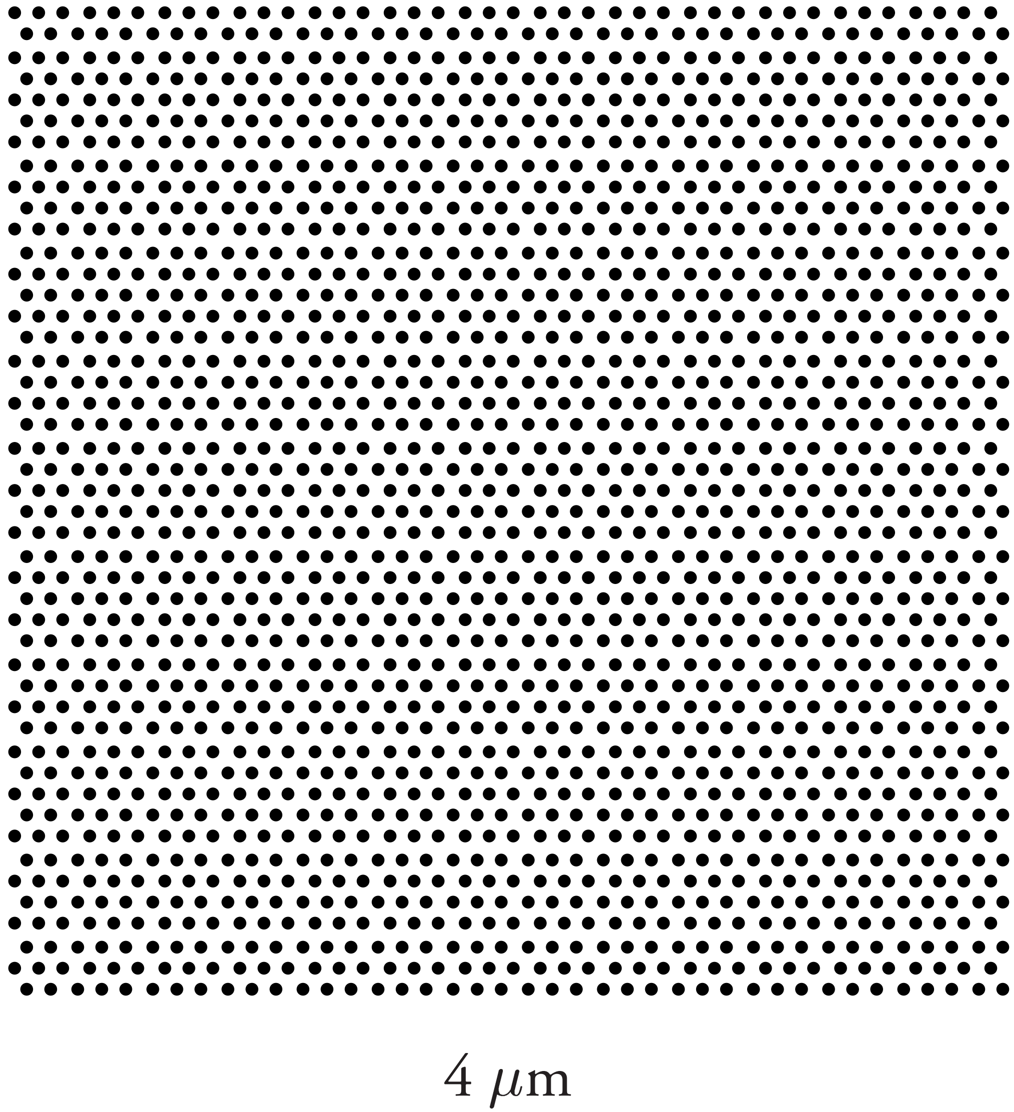


FIG. 5. Quasicontinuum mesh near the indenter after dislocation emission. The nodal positions correspond to representative atom sites. Dimensions are in Å.

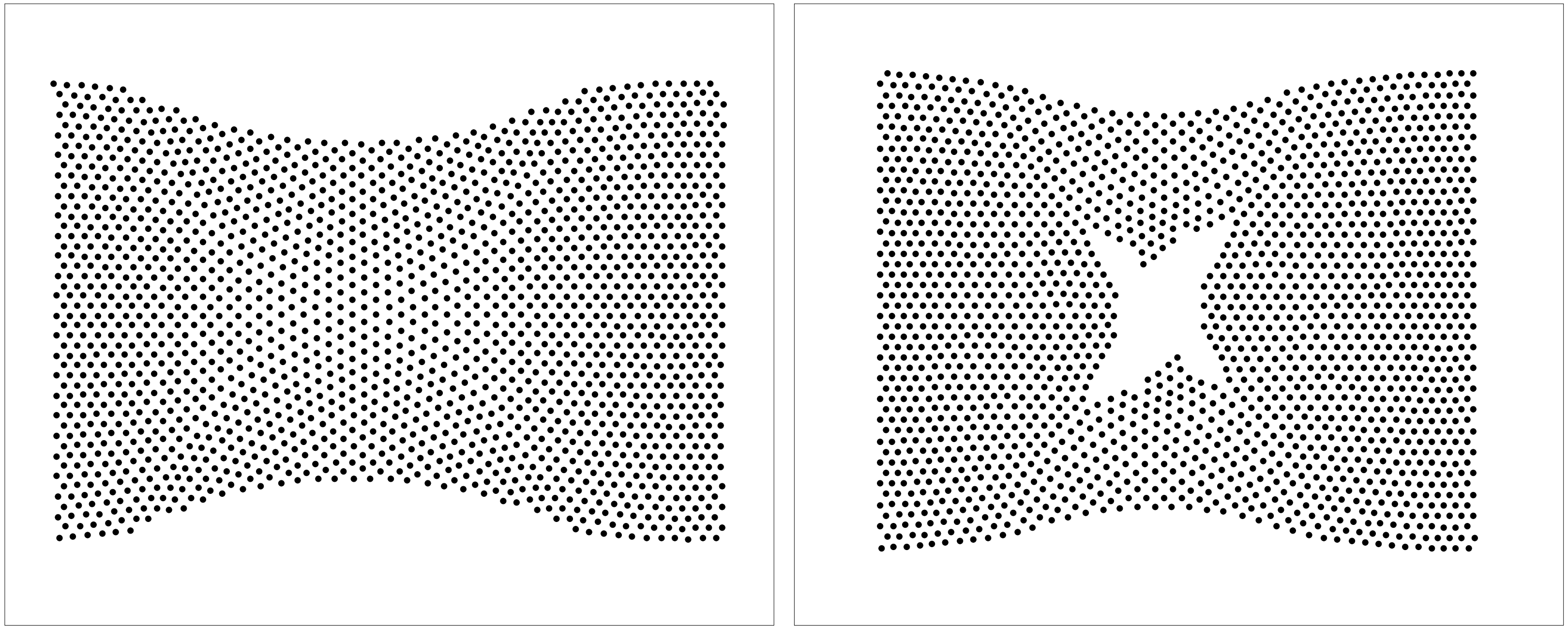
Top-down (continuum). E.B. Tadmor, R. Miller, R. Phillips, and M. Ortiz, J. Mat. Res. **14**, 2234 (1999).

Particle-based approach

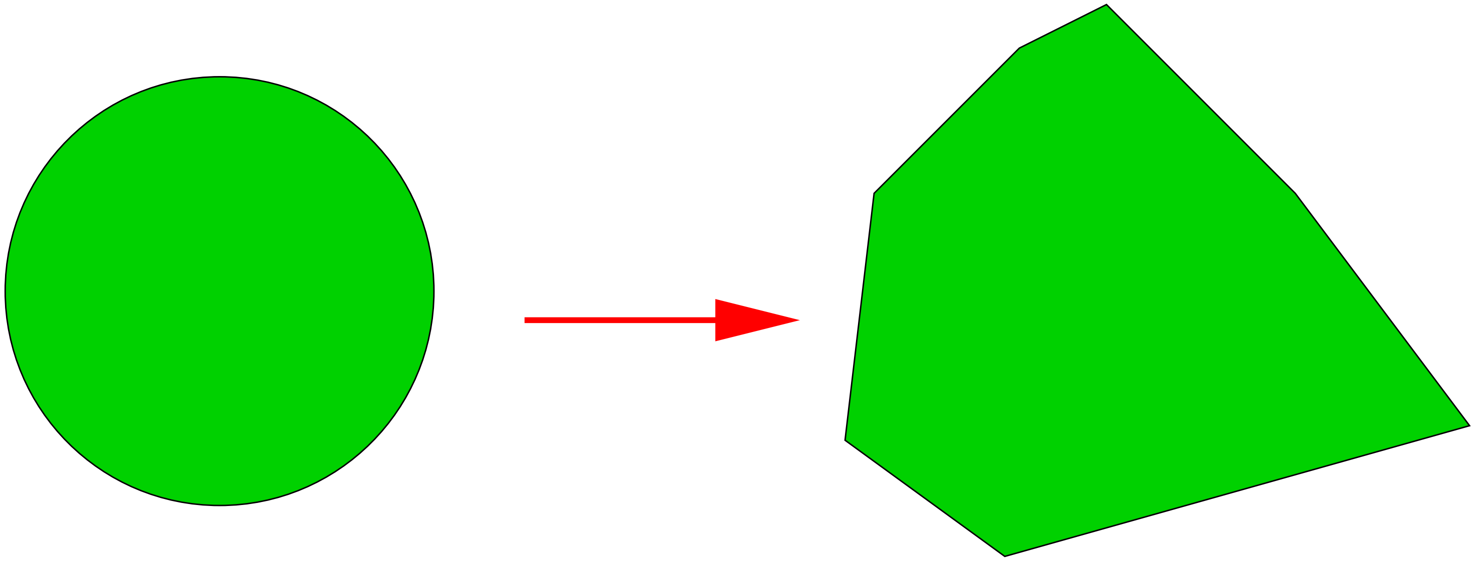




Mesograin Strain



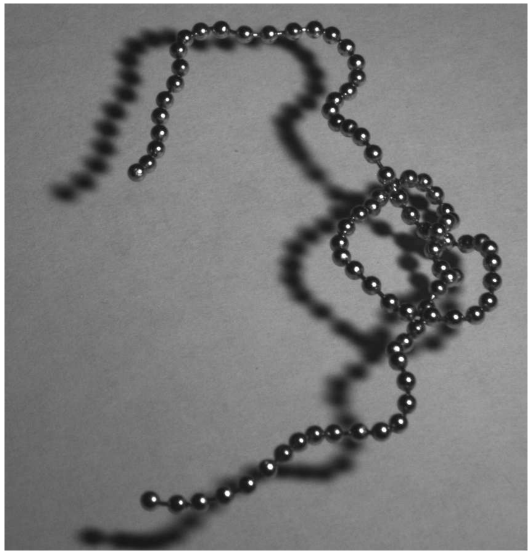
Irregular Grains

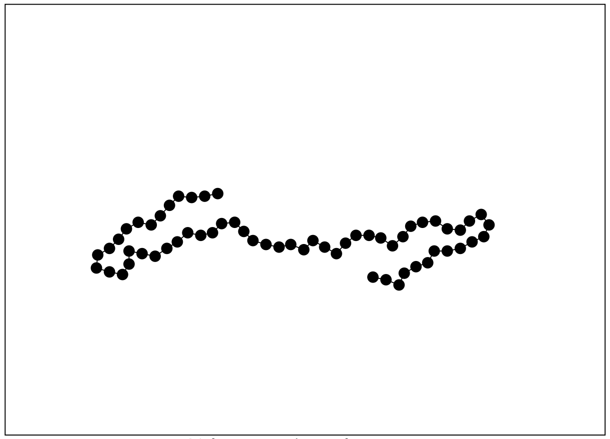


Consider *nonspherical* mesograin shapes

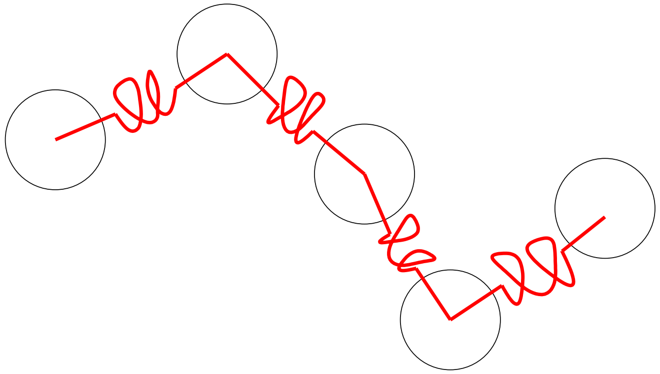
Granular chains

E. Ben-Naim, Z.A. Daya, P. Vorobieff, R.E. Ecke, PRL **86**, 1414 (2001)





Simulation



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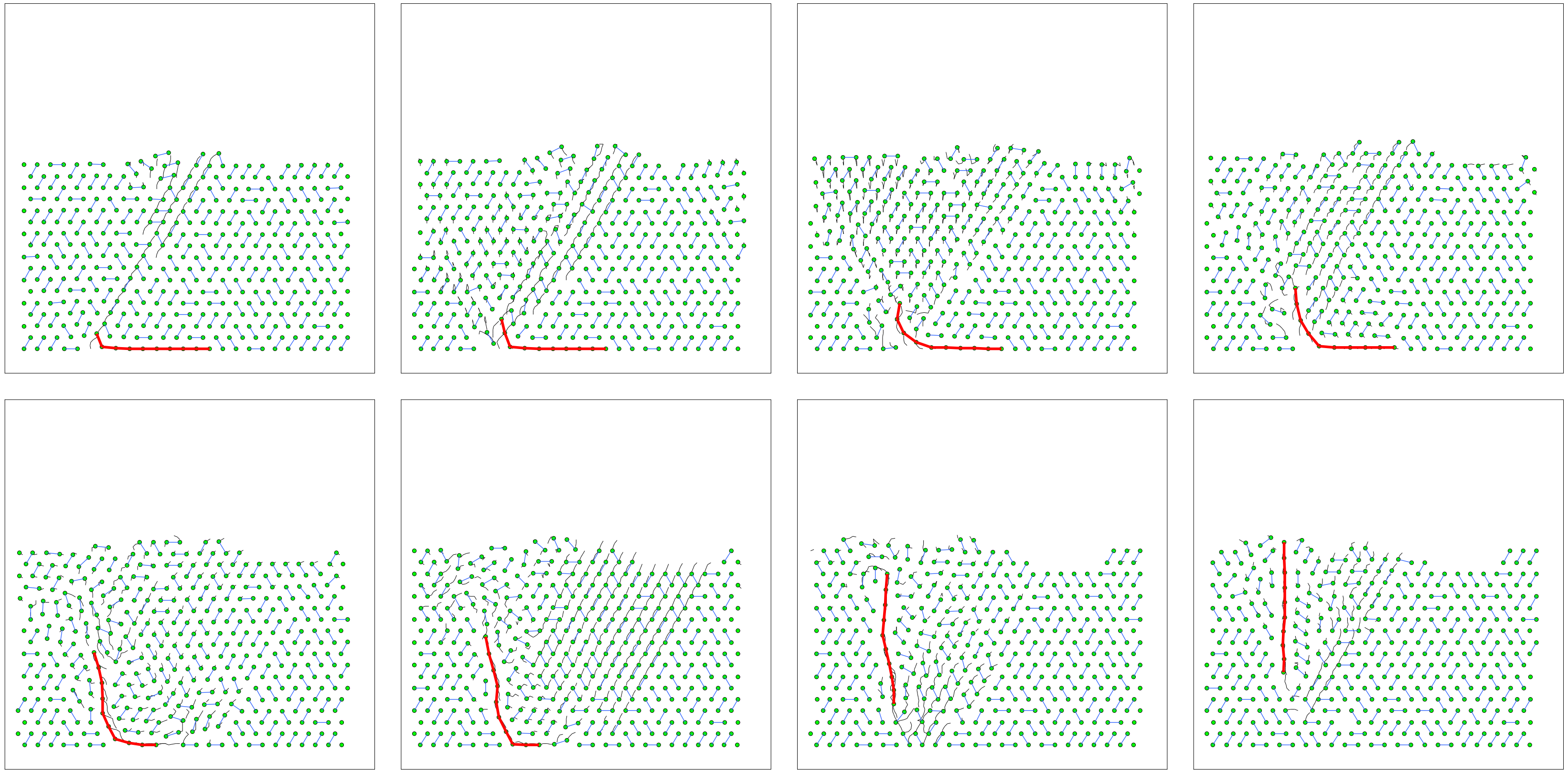
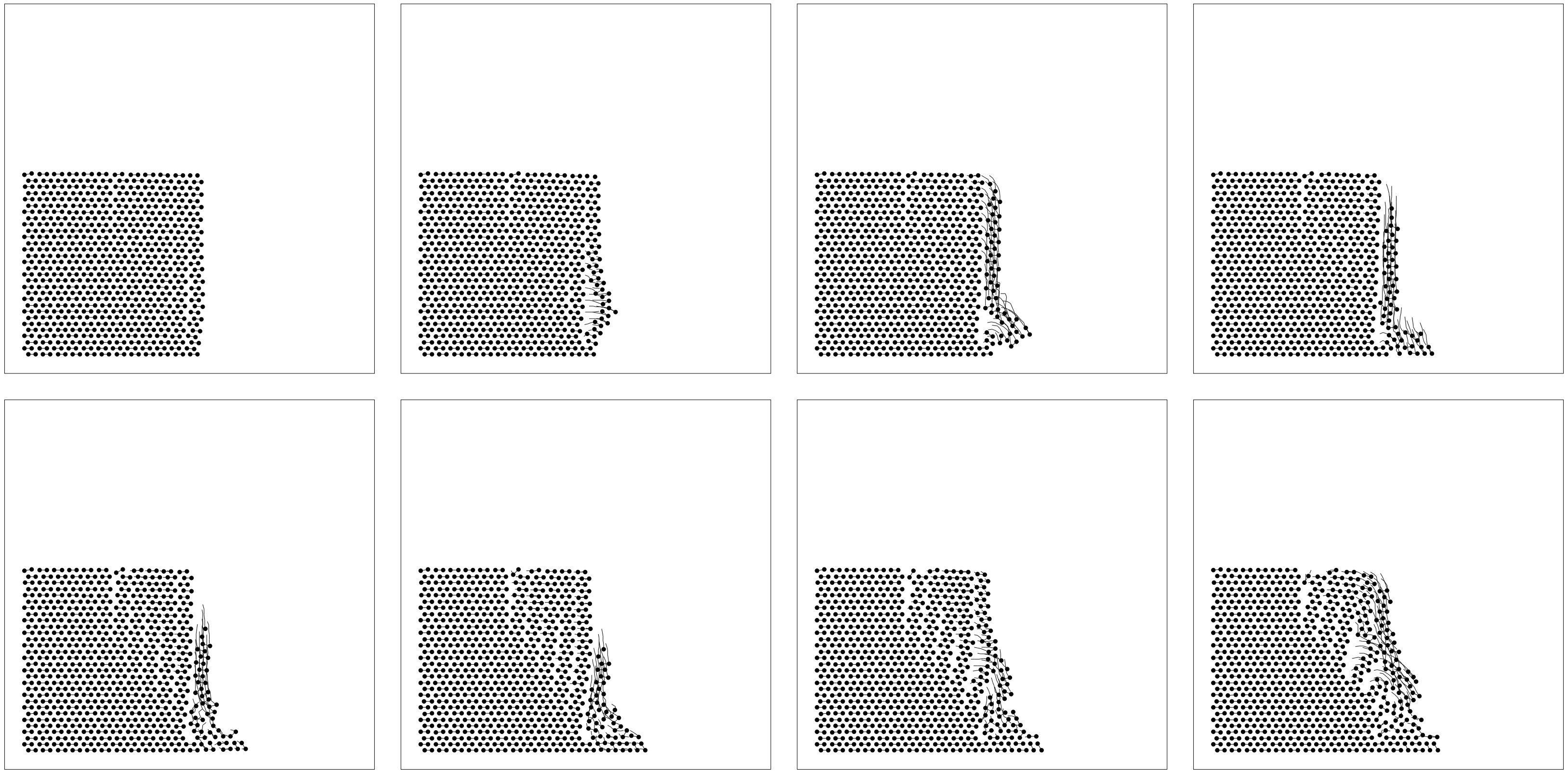
Granular Chain 10 in Monomer Packing

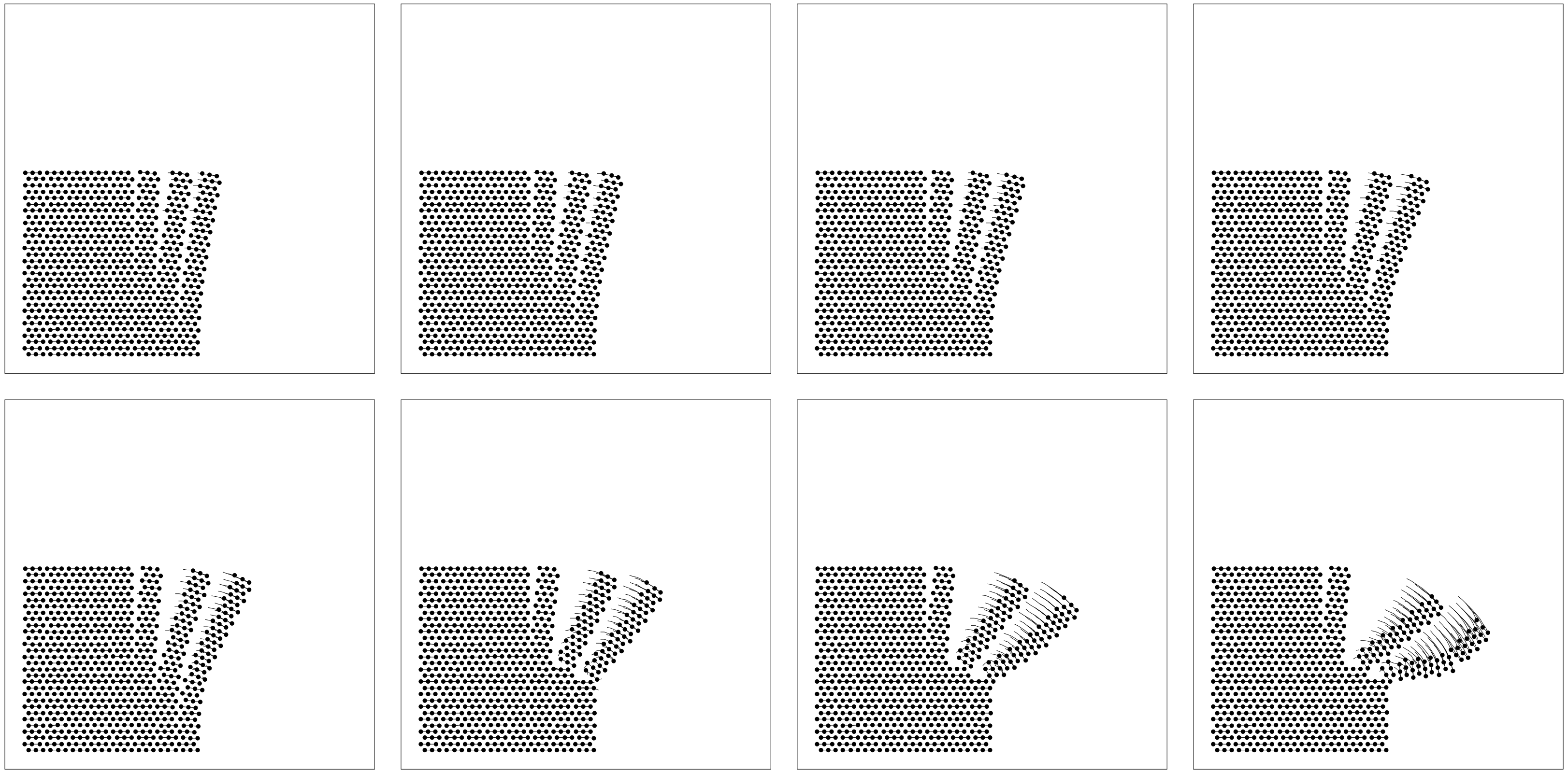
Granular Chain 10 in Dimer Packing



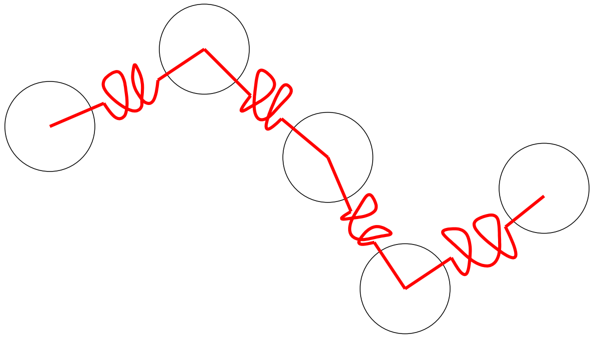
Ordered Dimers

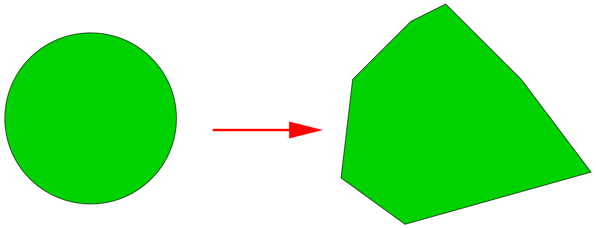


Ordered Trimers



Future Directions





- Particle-based granular simulations with constraints
- Simple linear elements show rich physics
- Stress transmission, force chains
- Granular chain model: "EOS," polymer-like behavior, traffic-like behavior
- Extension to mesoscale modeling
- Extension to 3D

Summary

- Using granular dynamics simulations we have explored the behavior of elongated grains and granular chains.
- Due to their symmetry, dimer grains show unique behavior including high angles of repose and reverse motion in a ratchet geometry
- The order of a granular packing can be tuned by varying the anisotropy of the grains, allowing an exploration of the effects of different kinds of disorder on stress transmission and dynamics
- A particle based approach offers insight into dynamics at scales much larger than atomistic.