Tata Institute of Fundamental Research
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Webinar

Fluctuations and Defect Interactions in Athermal Crystals

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Athermal materials represent a class of disordered systems where large-scale properties are only weakly affected by ambient thermal fluctuations. Examples include jammed packings of particles, low-temperature glasses as well as densely packed tissues. These systems display arrested dynamics and can be described purely by their energy or enthalpy minimized states.

We analyse the fluctuations in particle positions and inter-particle forces in disordered athermal crystals composed of jammed soft particles in the limit of weak disorder. We demonstrate that such athermal systems are fundamentally different from their thermal counterparts, characterized by constrained fluctuations of forces perpendicular to the original lattice directions. We develop a perturbation expansion about the crystalline ordered state, which we use to derive exact results to linear order. We show that constrained fluctuations result as a consequence of local force balance conditions, and are characterized by non-Gaussian distributions. We analytically predict several properties of such systems and verify with numerical simulations of soft disks with one-sided harmonic interactions.

We also focus on the nature of defects in the athermal crystalline system. We theoretically predict the strain fields and the change in forces produced by a single defect in a crystalline arrangement. We also derive the energy of interaction between defects placed at different locations in a crystalline athermal system. Using a similar method, we also predict the average interaction energy between defects placed at different locations in a disordered background and show an emerging power-law behaviour of the quantity. Finally, we predict the exact distributions of the energy of interaction between two defects on different disordered backgrounds.

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