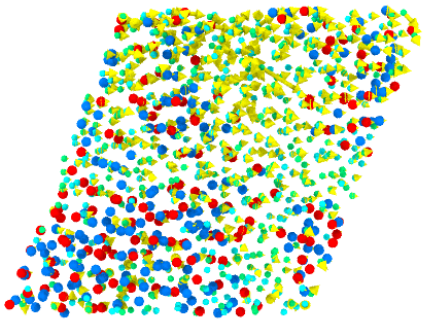
Phase transitions in trajectory space: the emergence of rigidity

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Shearing of a structure-rich configuration of a glassformer obtained via trajectory sampling. Local structure (blue and red dots) is mostly immobile while the rest of the system flows.

When liquids are rapidly cooled, their dynamics changes dramatically: the particle motion becomes **heterogenous** and **cooperative**, and the relaxation times rapidly exceed any human time-scale. Whether a genuine thermodynamic phase transition lies behind such a phenomenology is unknown. However, when computing time-integrated quantities, a measurable, well-defined transition in the space of multiple realisations of the liquid dynamics (**trajectories**) naturally emerges both *in vitro* and *in silico*. Employing the concepts of **locally favoured structures** and large deviations of **time-integrated observables**, we show that such *dynamical phase transition* corresponds to the existence of two (stable and metastable) liquid states of a model atomistic glass-former, separated by a free energy barrier that vanishes as we lower the temperature. **Shearing** such states connects the emergence of **rigidity** to the rare, highly structural phases accessible in the space of trajectories.