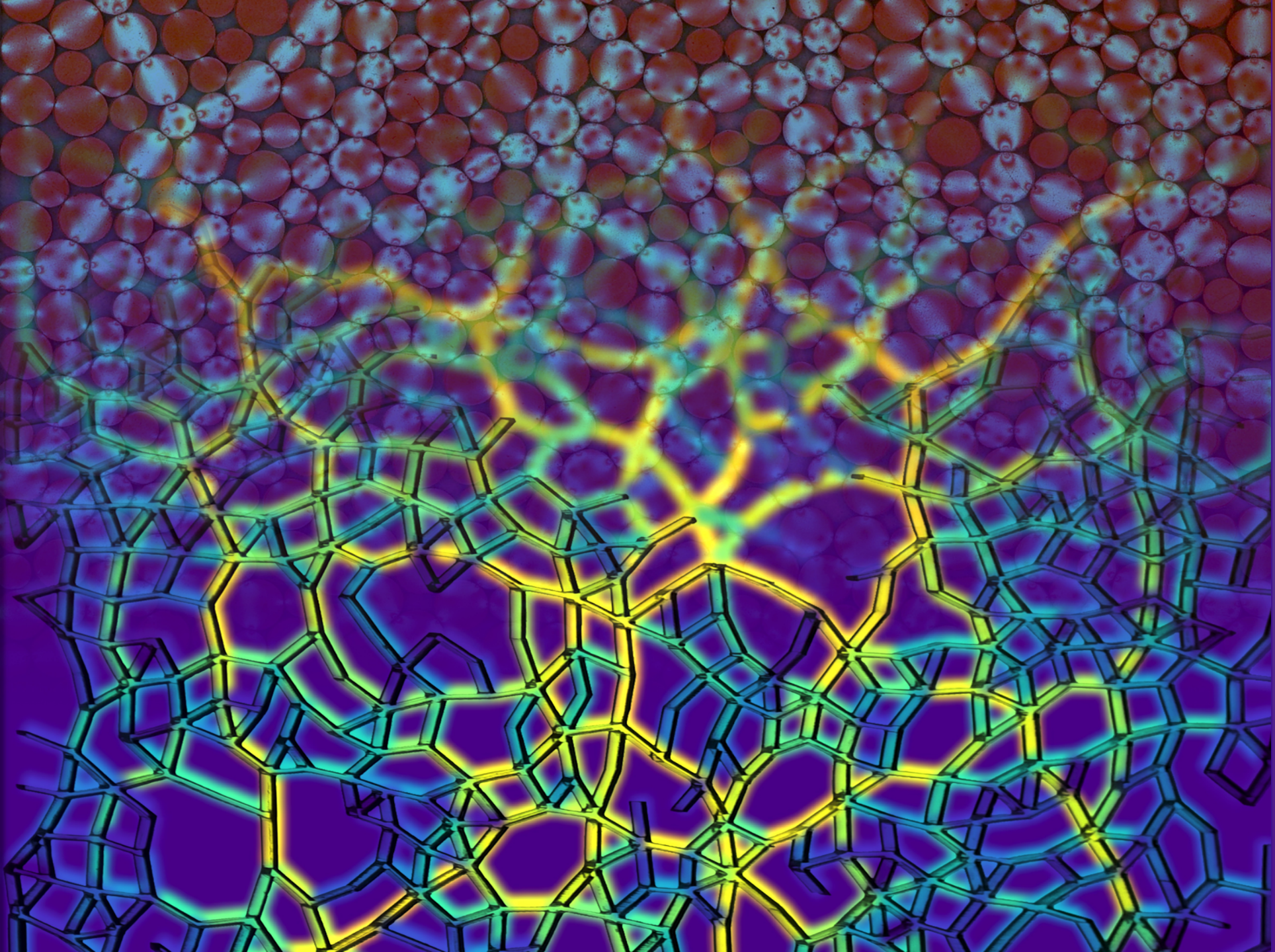

Granular Force Networks

Estelle Berthier[1,2]
Karen E. Daniels[2]
Mason A. Porter[3,4]

In granular packings of photoelastic particles, force chains are the networks of contacts between particles that transmit most of the load [2]. We see them in the top of the image, with particles in red and brighter regions indicating larger forces. Upon loading, the particles will rearrange. Can we relate the force network to such failure events?

We explore this question in an idealized framework. We laser-cut acrylic sheets to generate two-dimensional beam networks, which we depict in the foreground at the bottom of the image. We mechanically test the structure under uniaxial loading and we monitor the locations of beam breakages. Can we forecast where these failure events occur?

In a recent paper [1], we developed a method based on computing geodesic edge betweenness centrality (GEBC). We ranked the edges based on their ability to connect different parts of a network via shortest paths. Using a network that encodes the topology of the set of connected beams, we determined that most failures occur on beams whose GEBCs exceed the mean GEBC of a network. In the image on the left, we overlay the network's GEBCs, with brighter colors indicating larger GEBC values.

Can we now use our method to forecast failure locations in granular packings? Stay tuned …

[1] Faculty of Physics, LMU München, Germany
[2] Dept. of Physics, NC State, USA
[3] Dept. of Mathematics, U. of California, Los Angeles, USA
[4] Santa Fe Institute, USA

[1] E. Berthier, M. A. Porter, & K. E. Daniels [2019], "Forecasting failure locations in 2-dimensional disordered lattices", *PNAS* **116**(34); 16742–16749

[2] L. Papadopoulos, M. A. Porter, K. E. Daniels, & D. S. Bassett [2018], "Network analysis of particles and grains", *J. Cplx. Networks*, **6**(4): 485–565

Work supported by the James S. McDonnell Foundation