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Shocks in fragile matter

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Non-linear sound is an extreme phenomenon typically observed in solids after violent explosions. But granular media are different. Right when they unjam, these fragile and disordered solids exhibit vanishing elastic moduli and sound speed, so that even tiny mechanical perturbations form supersonic shocks. Here, we perform simulations in which two-dimensional jammed granular packings are continuously compressed, and demonstrate that the resulting excitations are strongly nonlinear shocks, rather than linear waves. We capture the full dependence of the shock speed on pressure and compression speed by a surprisingly simple analytical model. We also treat shear shocks within a simplified viscoelastic model of nearly-isostatic random networks comprised of harmonic springs. In this case, anharmonicity does not originate locally from nonlinear interactions between particles, as in granular media; instead, it emerges from the global architecture of the network. As a result, the diverging width of the shear shocks bears a nonlinear signature of the diverging isostatic length associated with the loss of rigidity in these floppy networks.