Effects of Self-Organization on Transport in Granular Matter: A Networks Approach

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Granular matter may be one of the simplest prototypes of what have come to be regarded as complex systems – systems where simple interactions can lead to rich, often surprising, global behavior. For example, interparticle contacts in a granular system give rise to networks that are (1) heterogeneous, i.e., a few particles support high compressive force, while many others support relatively little, and (2) self-organized, i.e., spatially correlated strong forces tend to form a sub-network of interconnecting 'force chains'. Using numerical simulations, we investigate the influence of heterogeneity and organization on the transport properties of granular matter, with particular attention to heat conduction – a phenomenon of ubiquitous importance in engineering and nature. We find that self-organization in the granular network promotes efficient transport. Furthermore, a network attack experiment suggests that contacts with high betweenness centrality, not necessarily those with highest local heat transfer coefficient, most significantly influence transport behavior. We find that concepts of network theory yield valuable insight – both qualitative and quantitative – into the observed behavior.

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