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Measuring the dynamics of transient networks in ferrogranulate: are there TWO timescales in only One constituent?

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We are reporting experiments on the aggregation dynamics of horizontally confined magnetized steel spheres, subjected to vertical vibration. Upon a sudden decrease of the shaking amplitude, the mm-sized spheres undergo a transition from a dispersed to an aggregated state. For deep quenches, a transient network of spheres rapidly emerges and gradually coarsens into compact clusters. In contrast, moderate amplitude reductions lead directly to dense cluster formation without intermediate networking. Using structural and network metrics such as coordination number and its mean value, we identify two characteristic timescales: a fast one governing the head-to-tail chaining typical of dipolar hard spheres (DHS), and a slower one corresponding to the restructuring into compact aggregates. The latter is driven by the intrinsic susceptibility of the beads but is challenged by inter-sphere-friction. By utilizing a pure ferrogranulate we corroborate that the employed susceptible dipolar hard spheres (SDHS) are a minimal model for phase separation with two intrinsic time scales in only one constituent. When adding glass beads, the coarsening dynamics retains its features, but the mean coordination number increases by 10%, indicating a better thermal coupling. Lowering the shaking amplitude, this mixture exhibits a non-monotonic behavior of the mean coordination number, resembling a "density anomaly".

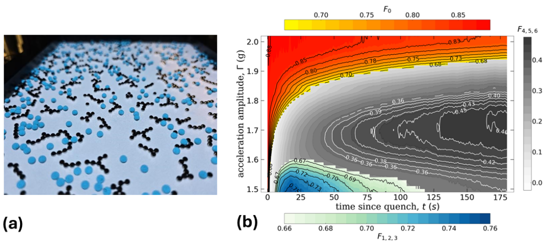

Figure 1: (a) Transient networks of magnetized steel spheres (black) in a granular gas of glass beads (blue). (b) Configuration diagram of three different ferrogranular states, that are gas-like (F_0), networks ($F_{1,2,3} = F_1 + F_2 + F_3$), and compact clusters ($F_{4,5,6} = F_4 + F_5 + F_6$). For a condensed overview the regimes where $F_0 > 2/3$ and $F_{1,2,3} > 2/3$ have been plotted in colour, and $F_{4,5,6}$ in the remainder in grey. The related colour codes are indicated at the top, bottom, and at r.h.s. From Lakkis et al. Soft Matter, vol. 22 (2026)

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