Idle active matter: excavation by confined and crowded collectives

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Ensembles of self-propelling elements can spontaneously form clusters, clogs and jams while accomplishing tasks in confined spaces. In some active materials/swarms, avoiding structure formation is important for task completion, for example, during nest formation by social insects like fire ants. We studied biological and mechanical collectives, including fire ant colonies, cellular automata models, and autonomous robots, to demonstrate the importance of appropriate individual and group-wide behaviours in facilitating tasks by crowded, confined active matter. We used tools from the study of glasses and dense particulate ensembles to provide insight into mechanisms by which congestion, jams and even arrest due to high-density traffic can be mitigated via group-level behaviours, such as idleness, as well as local interactions, such as selective retreats. A combination of these strategies are used by the ants and robustly emerge from optimization algorithms, enabling the largely idle active matter to perform a task without sophisticated sensing, planning and global control of the collective swarm.