Coordinating and reconfiguring arrangements of objects poses important questions at various dimensions, ranging from tiny particles all the way to far-away satellite swarms. Ironically, systems of these very small and very large distances share a fundamental property: It becomes difficult to use “external” computation, in which a powerful central computing device is provided with input about the system, and output is fed back into the system. Instead, it becomes important to consider “internal” computation, in which algorithms and execution remain within the system itself, even if that comes at the expense of processing power. Additional challenges arise from coordinating the parallel motion of larger and larger sets of objects in a globally efficient manner.

This talk will describe a variety of algorithmic approaches to coordination and reconfiguration. These are based on the work of our group and include: (1) Algorithmic aspects of “programmable matter”, i.e., algorithmic methods for controlling structures that can change their physical properties (shape, density, moduli, conductivity, optical properties, etc.) in a programmable fashion. (2) Optimization methods for coordinated motion planning, in which a large swarm of objects needs to be reorganized in a minimum amount of time. (3) Distributed approaches for coordinating the downlink activities of satellite swarms with more than 1000 spacecraft.

Despite the practical motivations and applications, the talk will contain a fair amount of theory, in part controlled by feedback from the audience.

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