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Harnessing Swarms to Optimize Transport of Interacting Active Particles

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Abstract

We investigate the potential of global control strategies to improve the transport efficiency of swarms of interacting self-propelled particles in confined geometries. Building on previous work [1], which showed that the uncontrolled system leads to wall-induced particle accumulation, clogging, and band formation due to both the self-organization dynamics and the channel geometry, we now investigate whether an external global control mechanism - such as an external magnetic field acting on all particles - can optimize the collective dynamics [2]. Using a discrete model with Vicsek-like interactions, we investigate how global alignment controls, optimized by reinforcement learning algorithms, can mitigate these unfavorable configurations and maximize the flux of particles in the streamwise direction.

[1] Calascibetta, Giraldi, El Khiyati and Bec. Phys. Rev. E 110, 064601 (2024).
[2] Calascibetta, Giraldi, El Khiyati and Bec. In preparation (2025).

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