Modes of Mechanical Guidance of Adhesion-Independent Cell Migration

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Adhesion-independent migration is a prominent mode of cell motility in confined environments, yet the physical principles that guide this movement remain incompletely understood. We present a phase-field model for deformable, non-adherent cells whose motility is driven by contractile cortical instabilities. The model couples surface and bulk hydrodynamics and includes a diffusible contractility regulator that drives cortical flows, making it well suited for complex geometries. Using this framework, we investigate how mechanical cues break symmetry to establish polarity and direct motion. We show that cells can spontaneously polarize and migrate in narrow channels, and that external cues – such as friction and viscosity gradients, geometric variations, imposed flows, and hydrodynamic interactions – can robustly steer migration. Beyond biological applications, this approach provides a generalizable phase-field methodology for modeling active surfaces, contractile instabilities, and hydrodynamic coupling.

References:

[1] https://doi.org/10.1039/d5sm00960j

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