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Cellular Hokey Pokey: A Coarse-Grained Model of Lamellipodia Protrusion Dynamics Driven by Fluctuations in Actin Polymerization

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Preview Abstract

Abstract

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Animal cells that spread onto a surface often rely on actin-rich cell extensions called lamellipodia to execute cell protrusion. XTC cells on a two-dimensional substrate exhibit regular protrusion and retraction of their lamellipodium, even though the cell is not translating. Travelling waves of protrusion have also been observed, similar to those observed in crawling cells. These periodic fluctuations in leading edge position have been linked to excitable actin dynamics near the cell edge using a one dimensional model of actin dynamics, as a function of arc-length along the cell. In this work we extend this earlier model of actin dynamics into two-dimensions (along the arc-length and radial directions of the cell) and include a model membrane that protrudes and retracts in response to the changing number of free barbed ends of actin filaments near the membrane. We show that if the polymerization rate of these barbed ends changes depending on their local concentration at the leading edge and the opposing force from the cell membrane, the model can reproduce the patterns of membrane protrusion and retraction seen in experiment. We investigate both Brownian ratchet and switch-like force-velocity relationships between the membrane load forces and actin polymerization rate.

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