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Models of actin dynamics and cell motility

Actin is a biopolymer that forms a major part of the cytoskeleton—the structure that endows shape and motility to animal cells. I will describe the work of Ph.D. student, Adriana T. Dawes (joint with Bard Ermentrout, and Eric Cytrynbaum) on the dynamics of the actin cytoskeleton and its relationship to the speed of motion of a cell. We derive a 1D model describing the density of actin filaments and their tips. In this model, we assume that actin tips push out the leading edge of the cell by the polymerization thermal ratchet mechanism (proposed by Mogilner and Oster, 1996). We include the effects of nucleation of new filaments, capping of their tips, as well as polymerization and disassembly of the filaments to arrive at a set of PDEs. In 1D, the model can be partly analysed in closed form to determine when travelling wave solutions (depicting steady state motion of a cell) exist, and how their speed depends on rate constants and biochemical parameters. Numerical simulations extend the results where analysis is cumbersome. We use the model to investigate the effects of three types distinct mechanisms of filament nucleation, and conclude that side branching best describes experimentally observed actin density distributions.