PHY420 Problems Class 4: Microtubules

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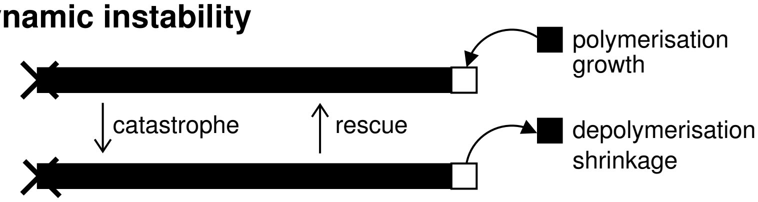
Microtubule dynamic instability



Consider a model for microtubules in which one end is fixed and the other end can be in 2 different states: a polymerising state growing at speed v^+ or a depolymerising state shrinking with speed v^-. Microtubules switch from a growing to a shrinking state with rate k_C (known as a "catastrophe"). Shrinking microtubules can switch back to a growing state with rate k_R (called a "rescue"). Denote the probability of a growing microtubule of length l as $P^+(l,t)$ and the probability of a shrinking microtubule of length l as $P^-(l,t)$.

1. Consider a system composed of only growing microtubules and no catastrophes. Show by using a Taylor expansion that the time evolution of probability $P^+(l,t)$ is given by:
$$\frac{\partial P^+(l,t)}{\partial t} = -v^+ \frac{\partial P^+(l,t)}{\partial l}.$$
[6]

2. Now consider a system of only shrinking microtubules and no rescues. Show that the time evolution of probability $P^-(l,t)$ is given by:
$$\frac{\partial P^-(l,t)}{\partial t} = v^- \frac{\partial P^-(l,t)}{\partial l}.$$
[6]

3. Using your answers to parts 1 and 2 write down the coupled Master equations for $P^+(l,t)$ and $P^-(l,t)$ in the full system with both growing and shrinking microtubules and catastrophes and rescues. [4]

4. Solve the master equations in steady state assuming the lengths are bounded such that $P^+(l \to \infty, t) = P^-(l \to \infty, t) = 0$. [8]

5. Sketch a graph of the length distribution $P^+(l)$ and an example sketch of the behaviour of the length over time. [4]