Continuing Cytoskeleton modeling

Microtubules

Microtubules are dynamic structures involved in various cellular processes. They are composed of tubulin dimers and can exist in different states such as growing and shrinking.

Molecular Motors

Kinesin is a molecular motor that runs to the plus end of a MT. Show movie! (Ron Vale, UCSF)
dynein is a molecular motor that runs to the minus end of a MT

How can modeling be useful in these kind of problems?

Very recent example:
Goshima et al. Length control of the metaphase spindle

What determines the length of the spindle?
Three forces:
Force I: Sliding force forcing centrosomes apart

Three forces:
Force II: Kinetochore pulls centrosome inwards

Three forces:
Force III: Restoring spring forces tries to keep spindle length at $S_o$. 

\[
\begin{align*}
\frac{dS}{dt} &= 2(V_{\text{sliding}} - V_{\text{depolysliding}}) \\
\frac{dL}{dt} &= 2(V_{\text{poly}} - V_{\text{sliding}}) \\
\frac{dS}{dt} &= \frac{1}{\mu} 2(F_{\text{sliding}} - F_{k_t} - F_{\text{tension}}) \\
F_{\text{sliding}} &= \alpha L \left( 1 - \frac{V_{\text{sliding}}}{V_{\text{sliding,max}}} \right) \\
F_{\text{tension}} &= \beta (S - S_o) \\
F_{k_t} &= F_{k_{t,0}} \\
\end{align*}
\]

Problem:

Depolymerization rate depends on \( F_{\text{sliding}} \)

Probability to find minus end of MT a distance \( x \) away from centrosome:

\[
P(x) \sim \exp \left( -\frac{(F_{\text{sliding}} / N)x}{k_B T} \right)
\]

Probability to find it within a distance \( \delta \):

\[
P(x < \delta) = 1 - \exp \left( -\frac{(F_{\text{sliding}} / N)\delta}{k_B T} \right)
\]

Therefore, \( V_{\text{depolysliding}} \) is not constant:

\[
V_{\text{depolysliding}} = V_{\text{depolysliding,0}} + V_{\text{depolysliding,max}} \exp \left( -\frac{(F_{\text{sliding}} / N)\delta}{k_B T} \right)
\]

Now this systems of equations has a steady-state.
Shameless advertisement ...

http://www.mbl.edu/education/courses/summer/course_physio.html

Second example:


Black tetra