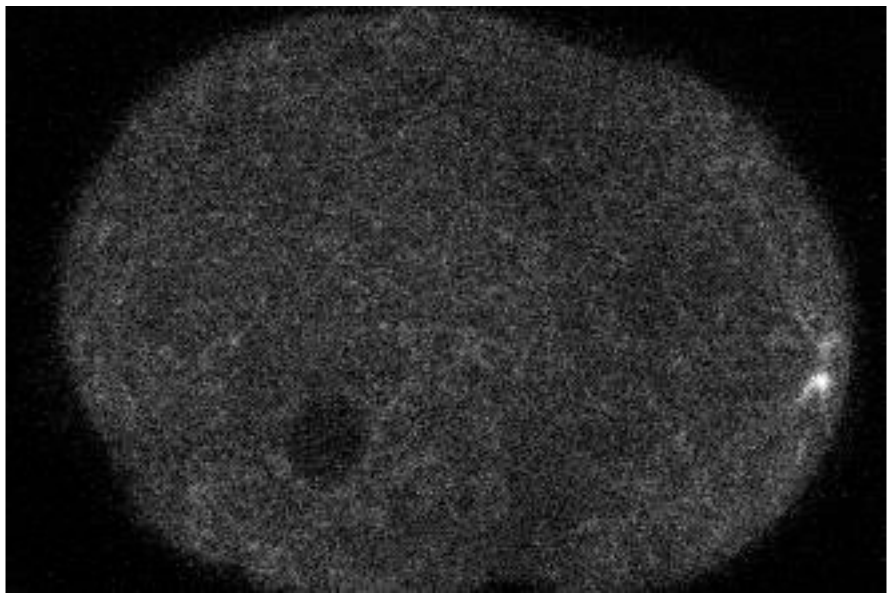
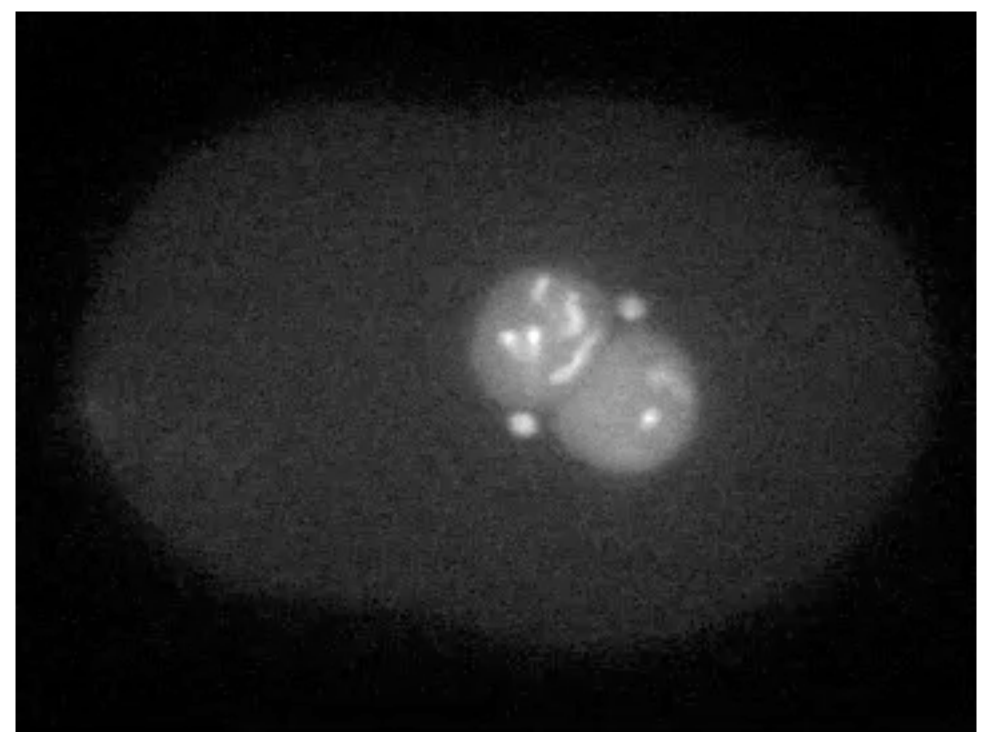
Cytoskeleton-based positioning during development, cell division



C elegans fertilization - pronuclei migration and reorientation
Ed Munro and Chris Schoff (Center for Cell Dynamics)

C elegans fertilization - chromosome alignment and segregation
George von Dassow (Center for Cell Dynamics)



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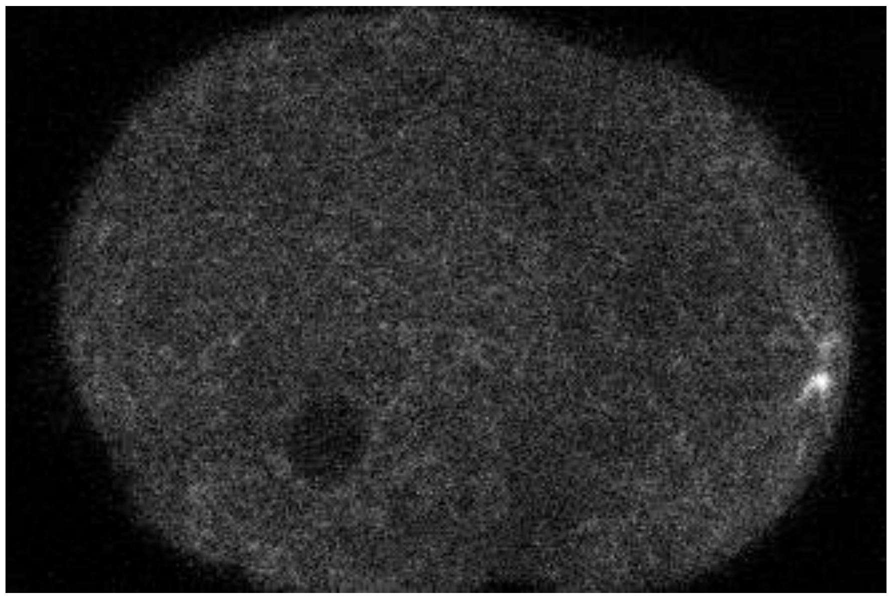

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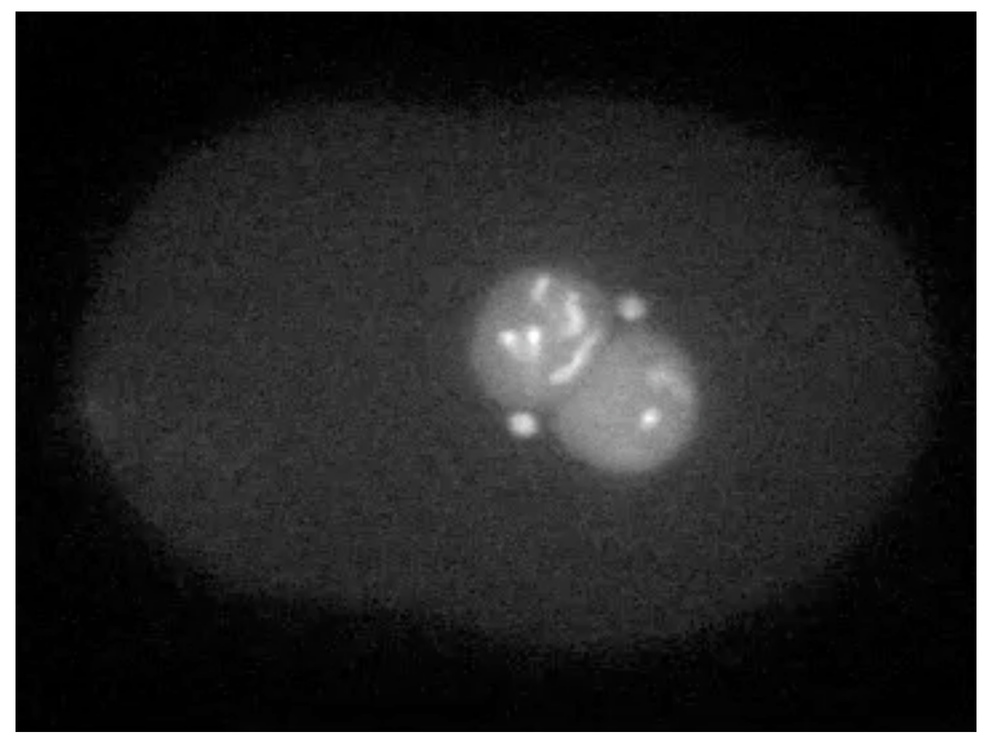

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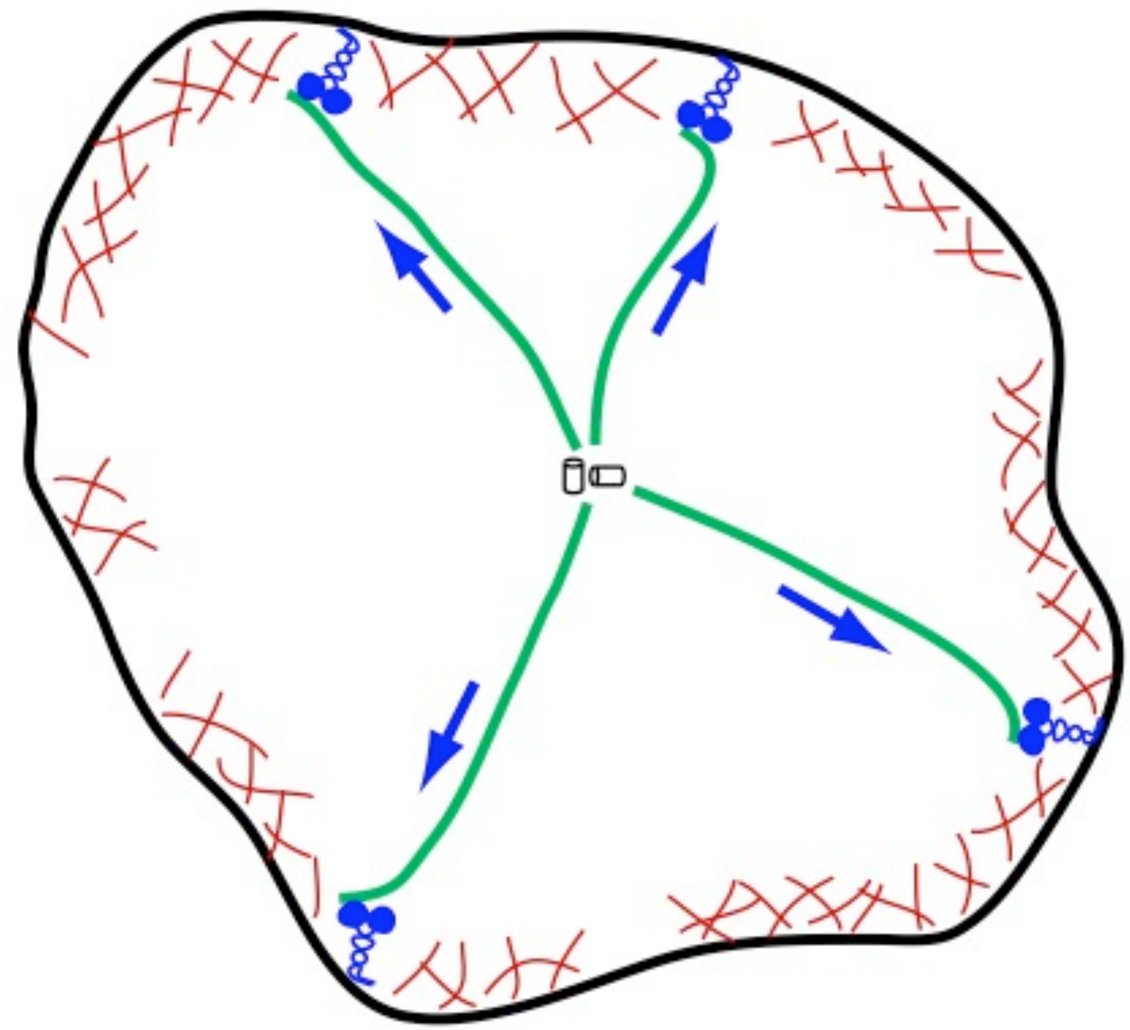

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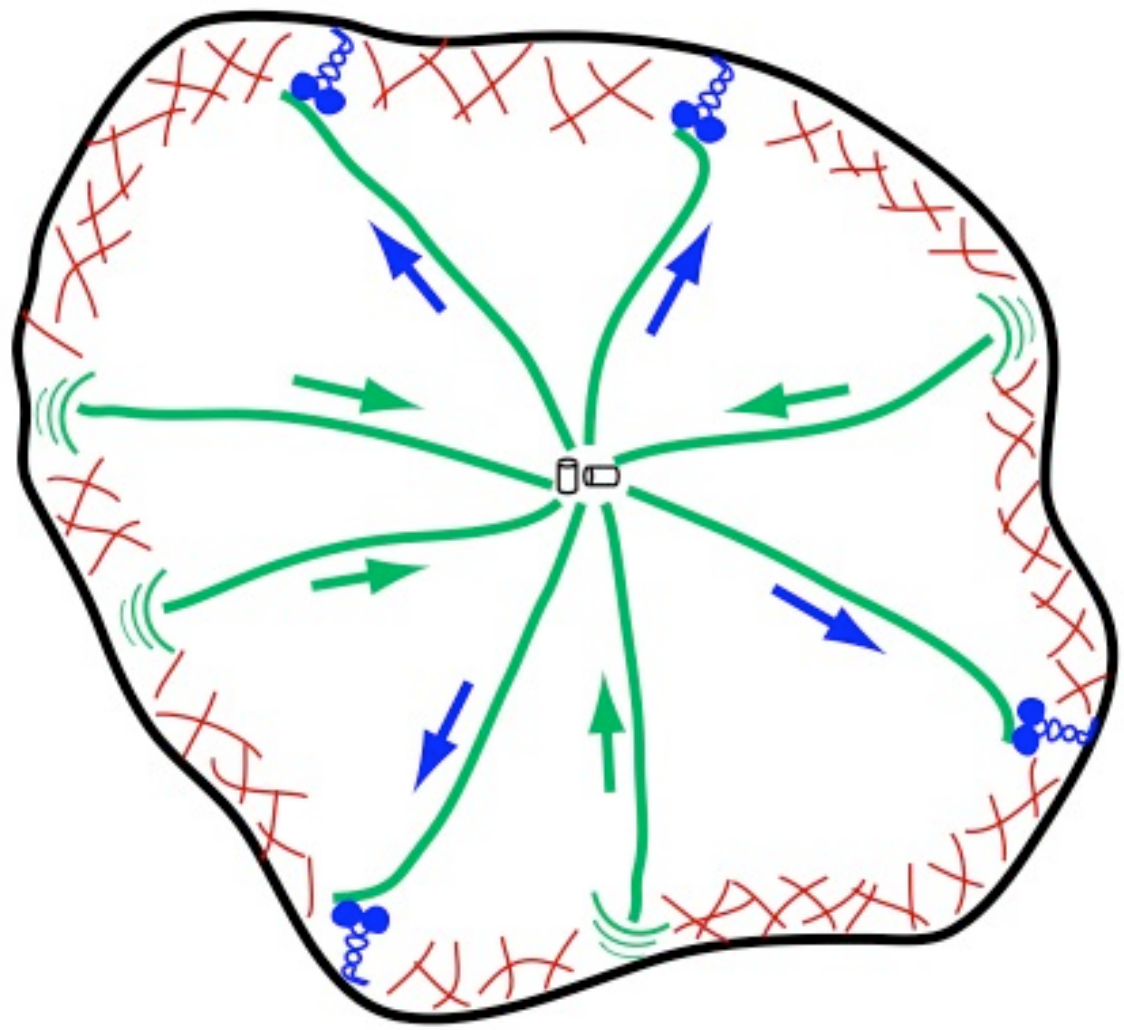

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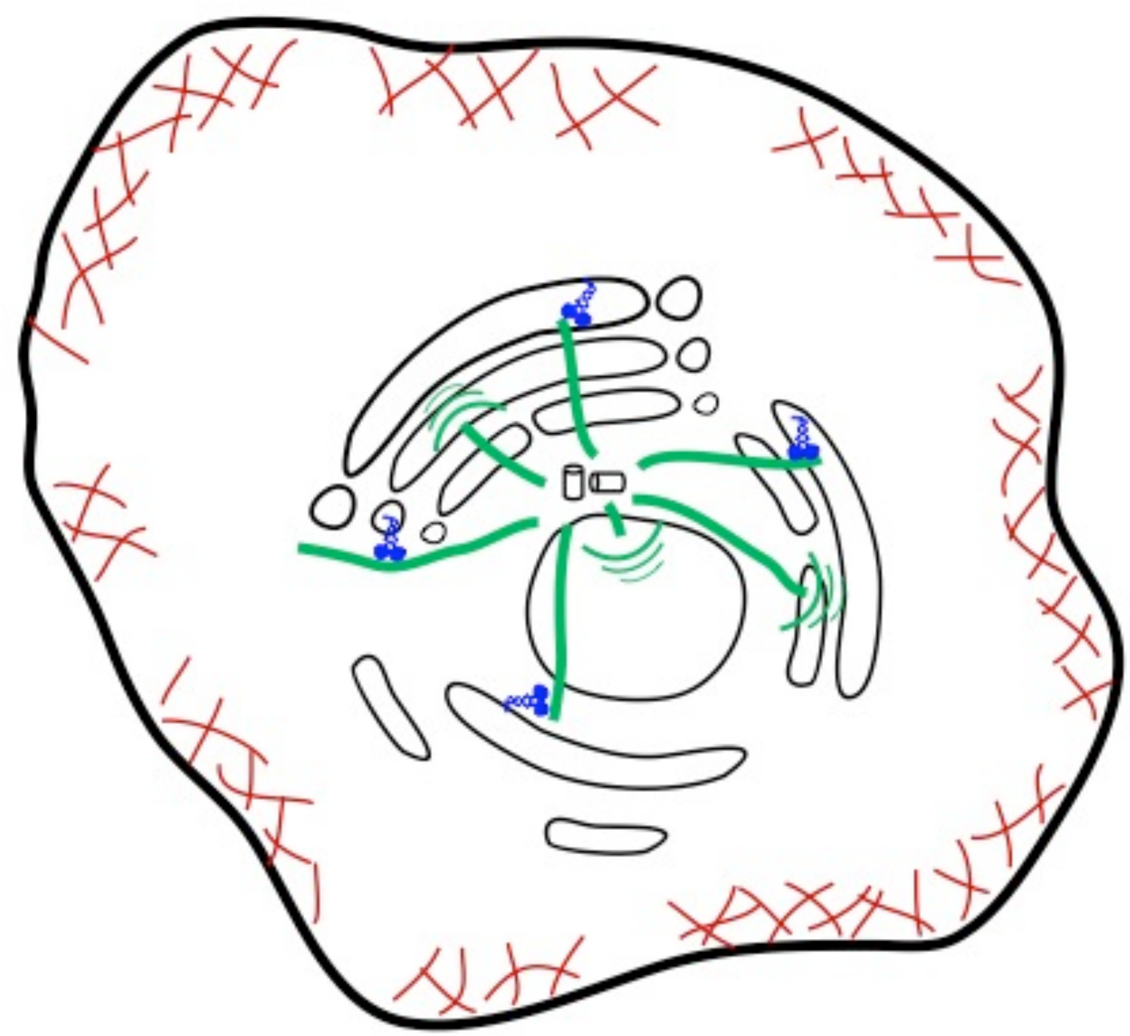
- Cortical dynein pulls on aster.
- MTs push against cortex by polymerizing.
- Motors push/pull against organelles.



Forces, steady states and their stability

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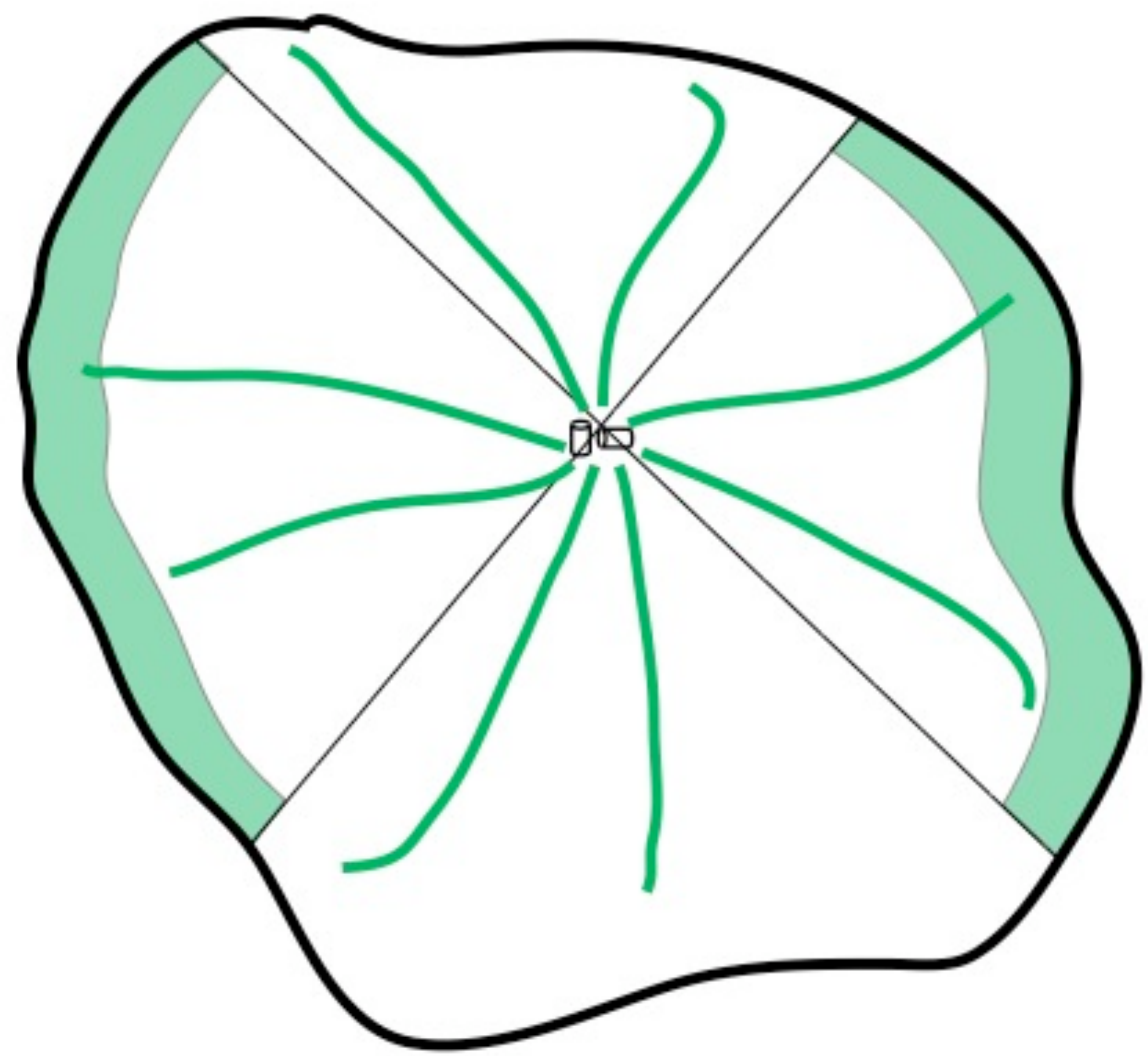
- Cortical pulling - destabilizing.



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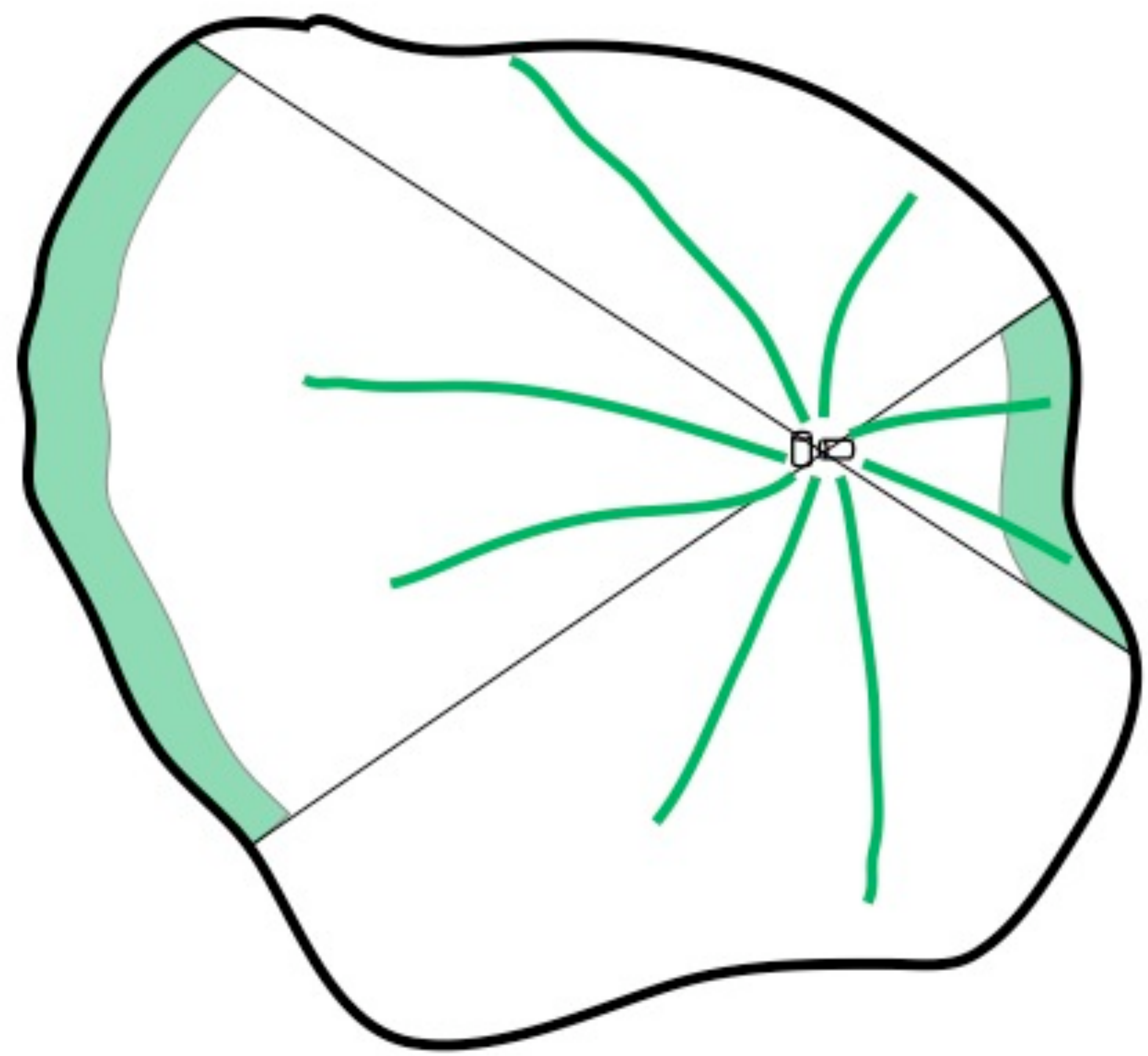

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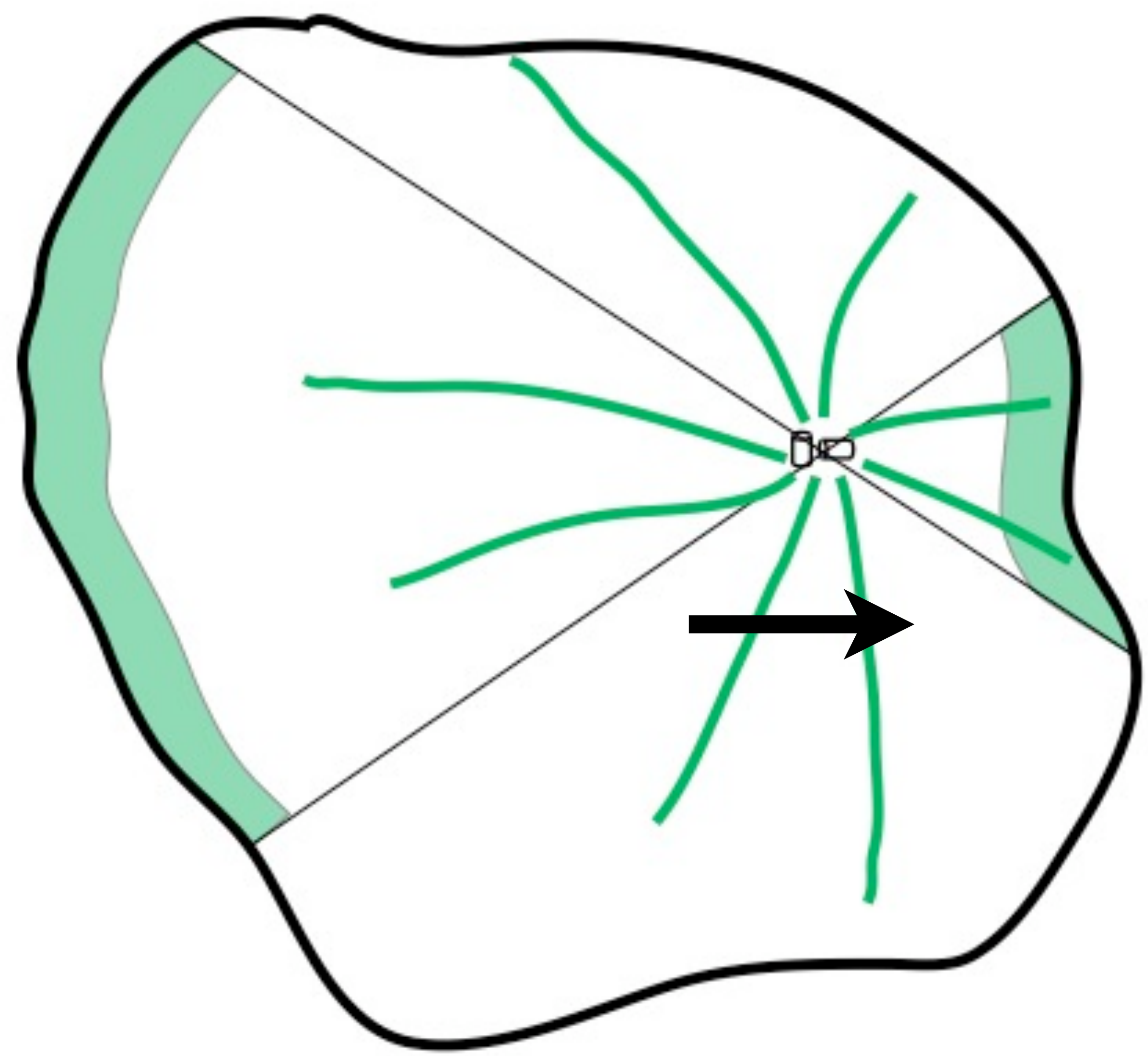

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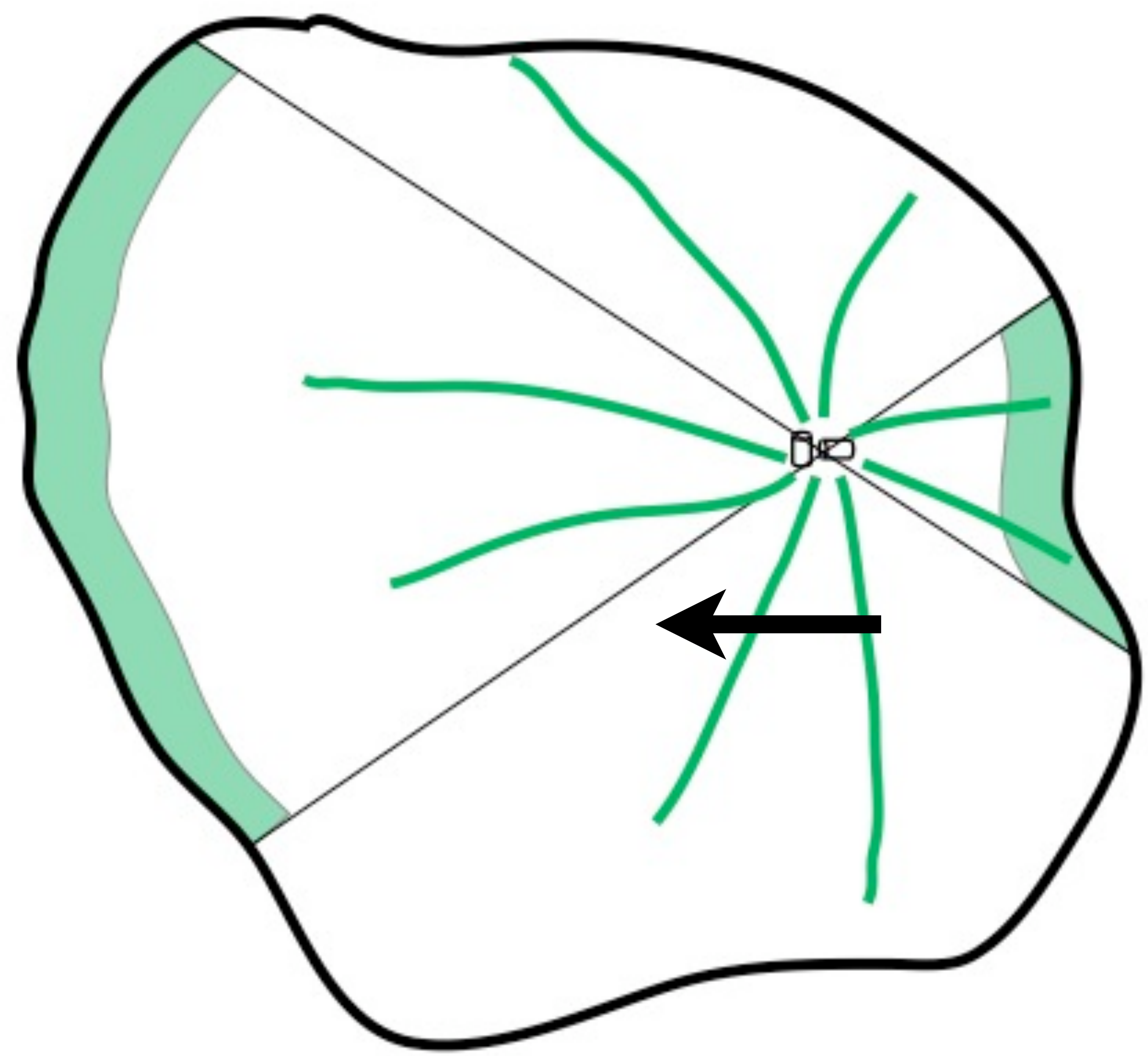

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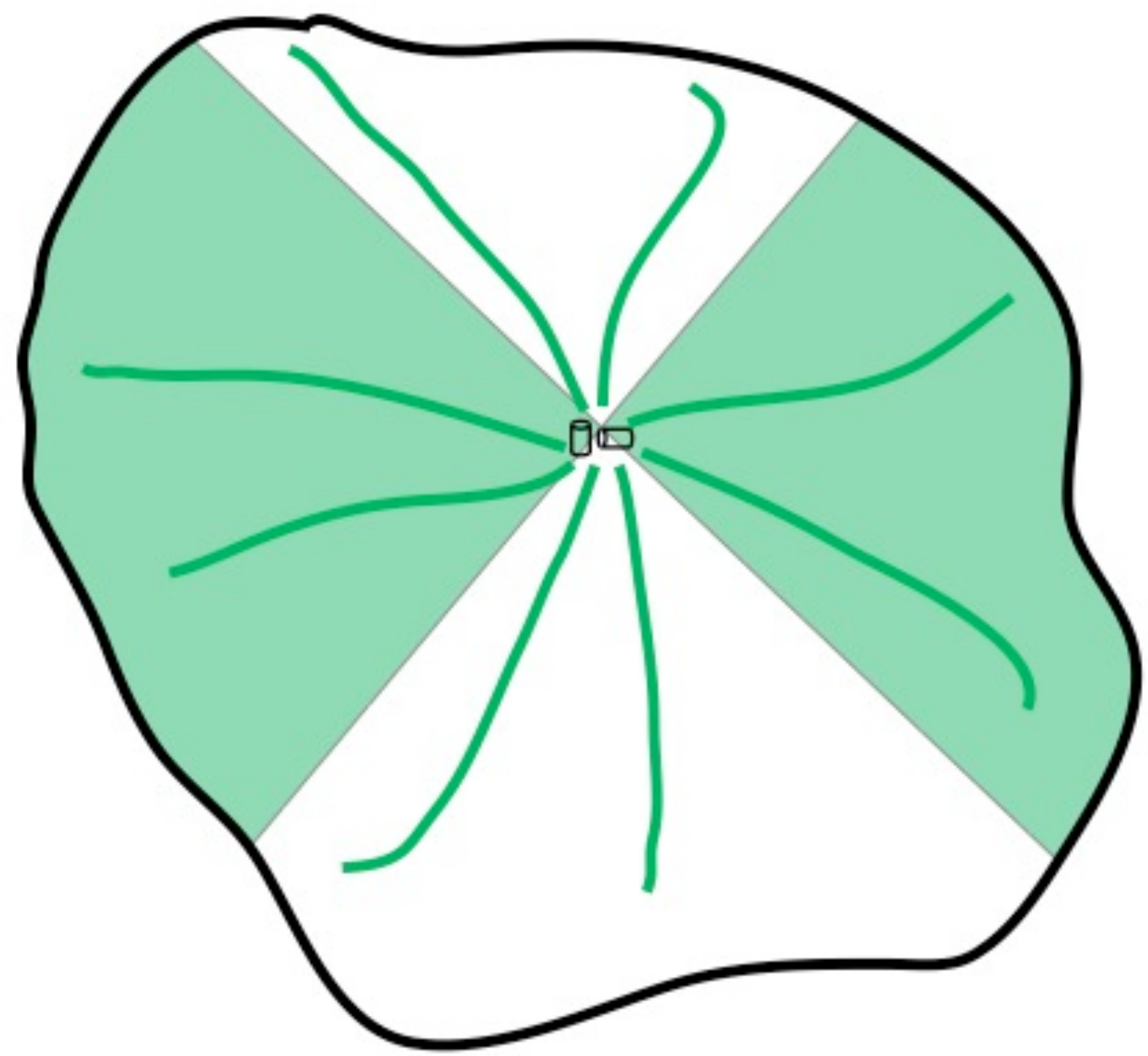

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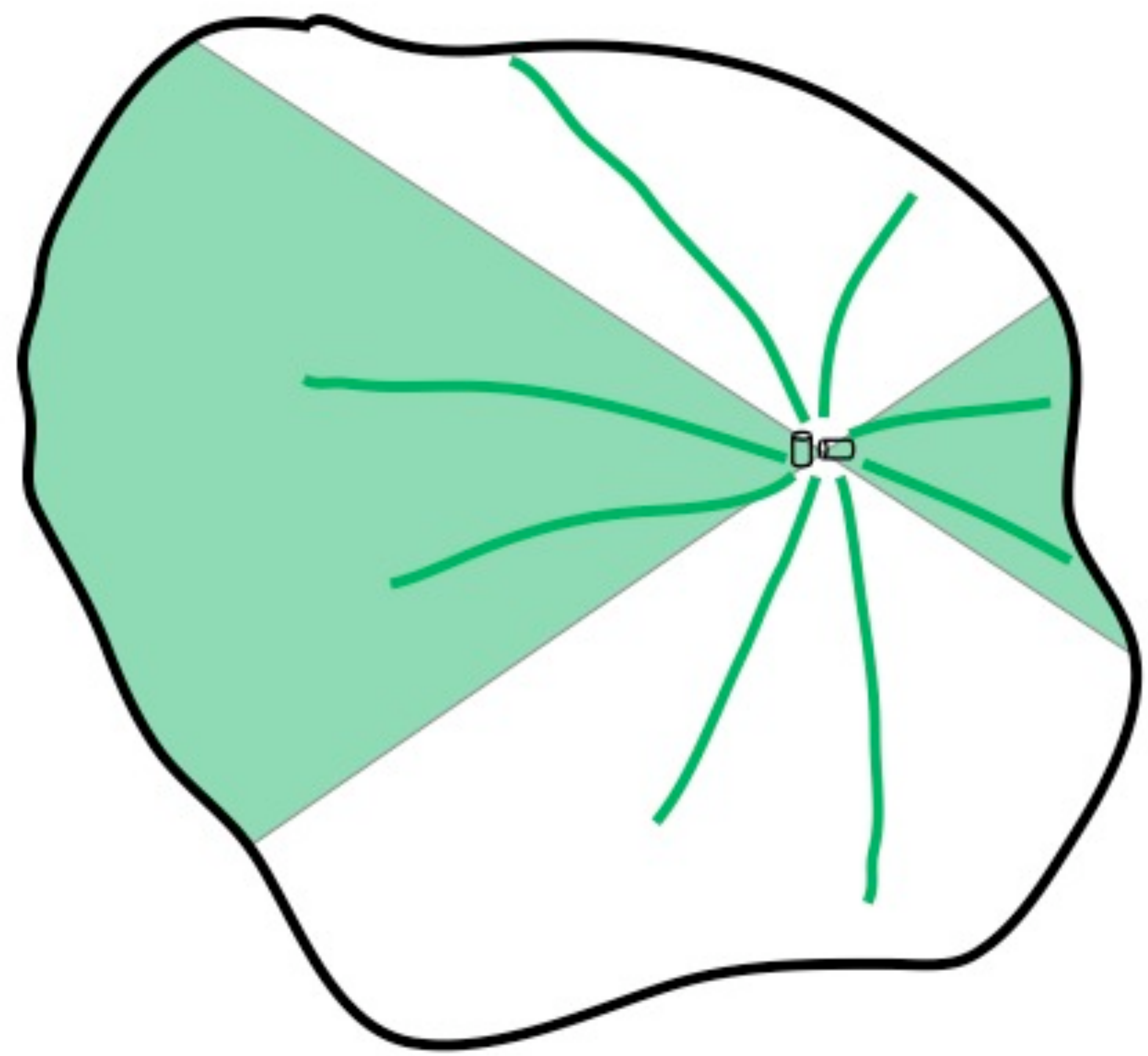

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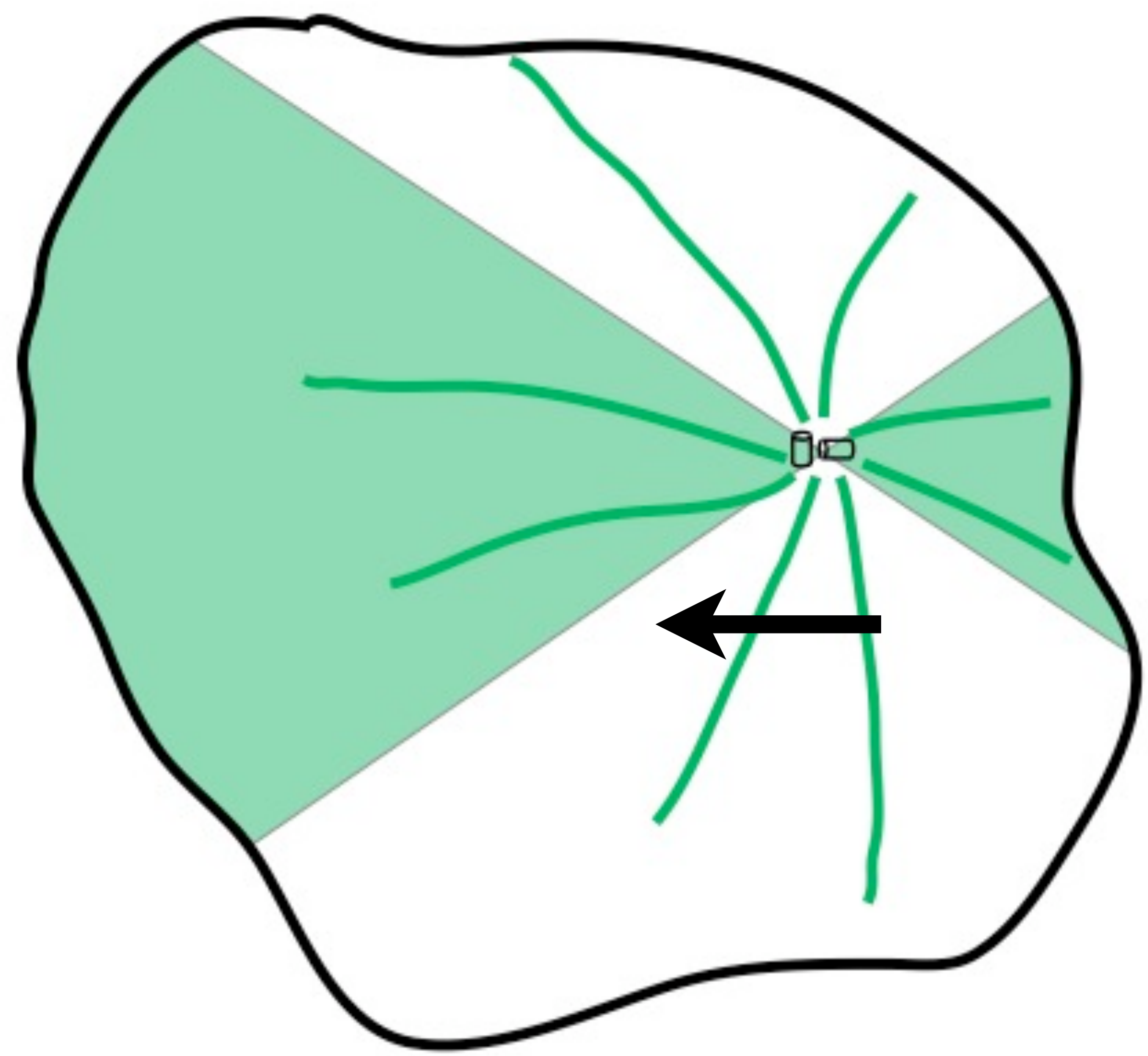

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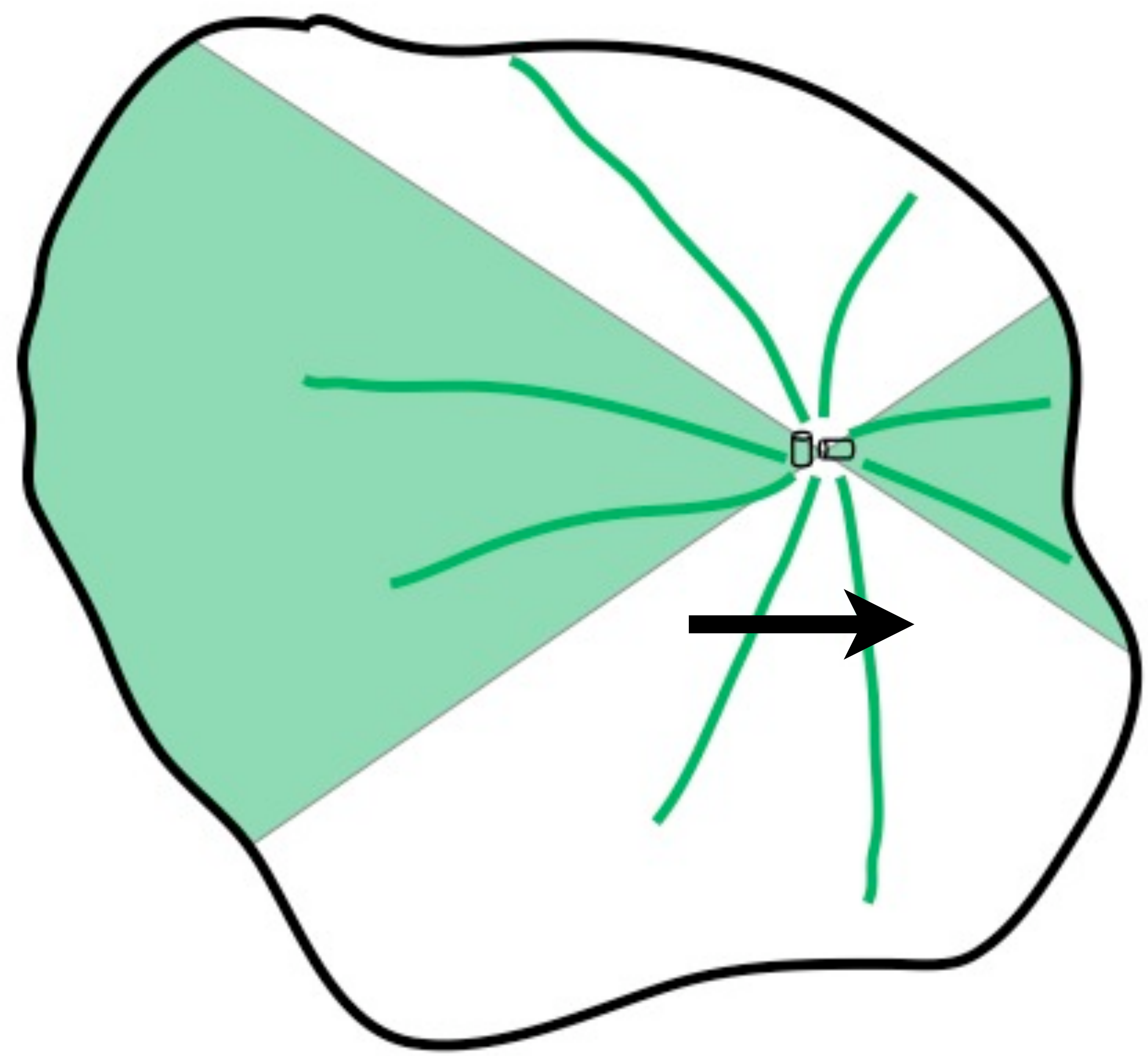

Two-D simulation - cytoplasmic pulling

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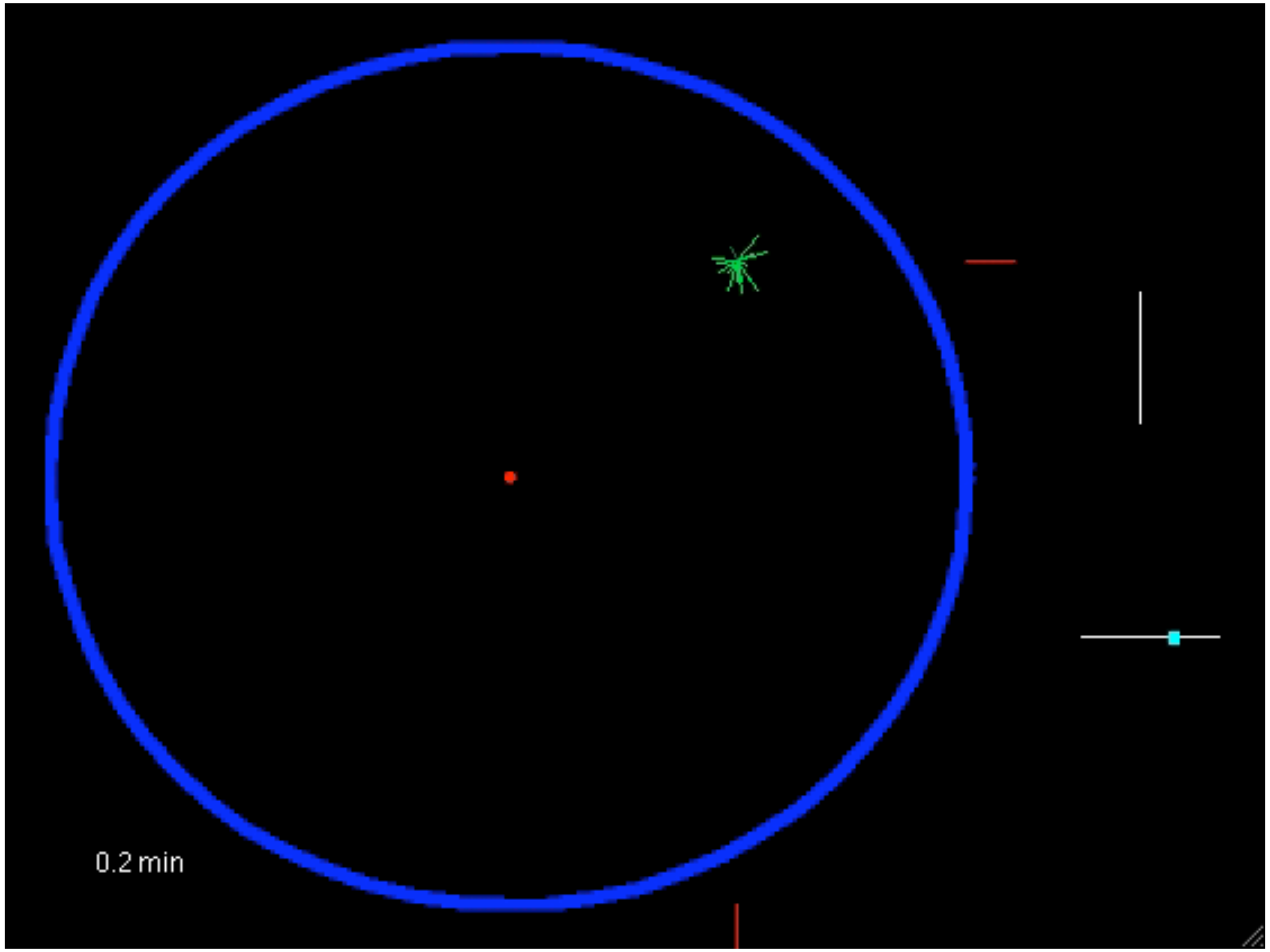

One-D model of motor-based centering

Microtubule (MT) dynamics - stochastic transitions between growing and shrinking states

$$\frac{\partial g}{\partial t} = -v_g \frac{\partial g}{\partial l} - cg + rs$$

(density of growing MTs)

$$\frac{\partial s}{\partial t} = v_s \frac{\partial s}{\partial l} + cg - rs$$

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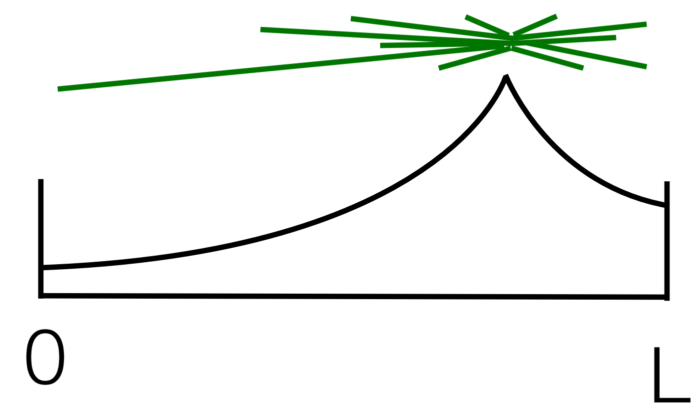
$$g(l) + s(l) = Ae^{-\lambda l} \quad \left(\text{where } \lambda = \frac{v_s c - v_g r}{v_g v_s}\right)$$

(density of MT of length l)

One-D model - calculating forces from MT densities

$$Tips(x) = Ae^{-\lambda|x-x_c|}$$



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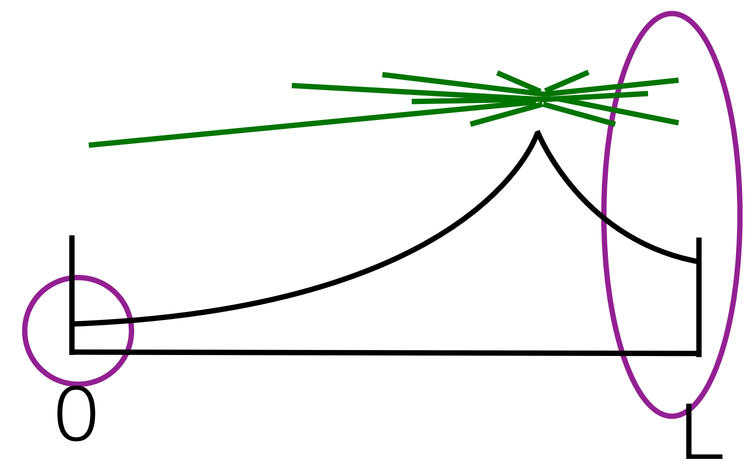

If motors pull only at the cell periphery,

$$F_{pull}(x_c) = B(-e^{-\lambda x_c} + e^{-\lambda(L-x_c)})$$

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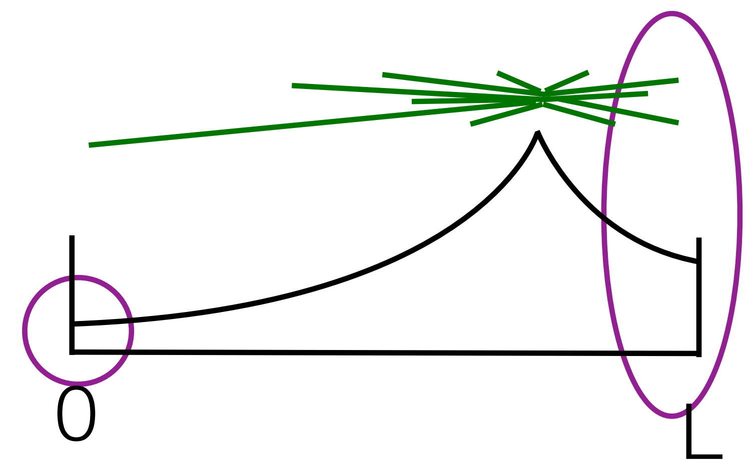

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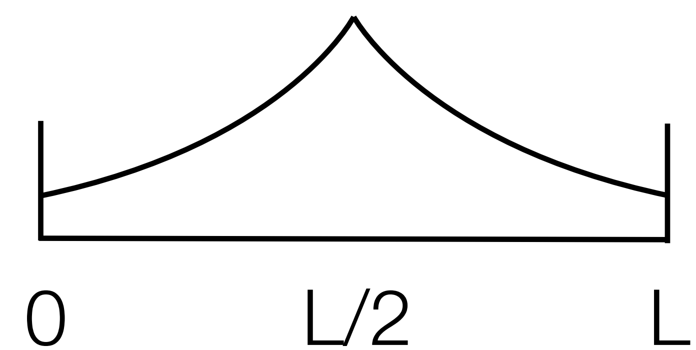

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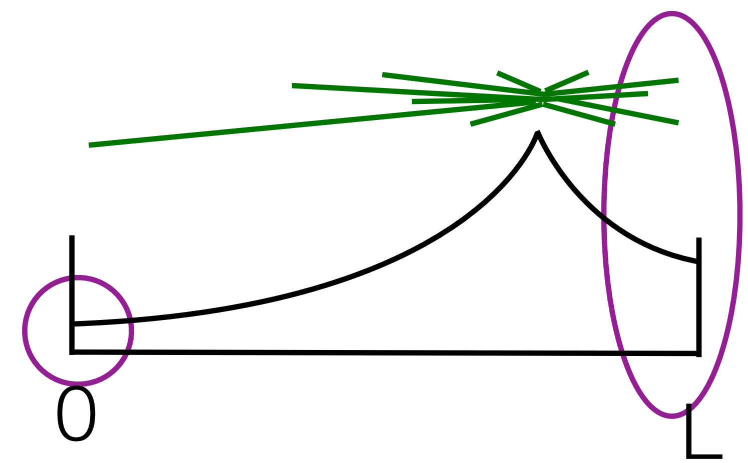

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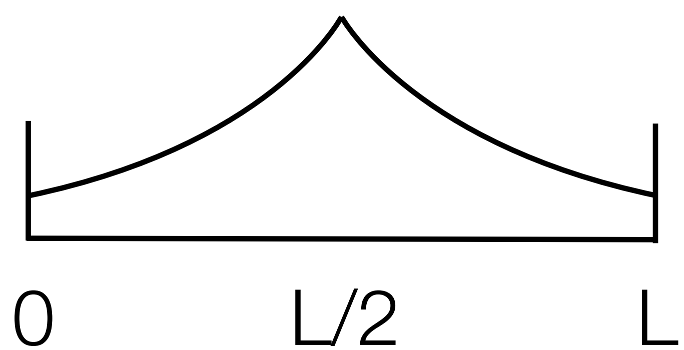

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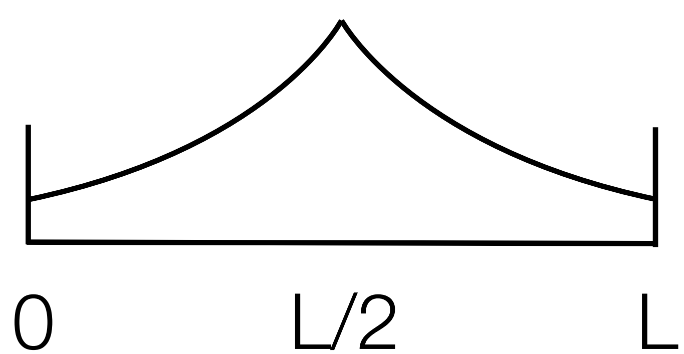
For stability, check derivative of F_{pull} :



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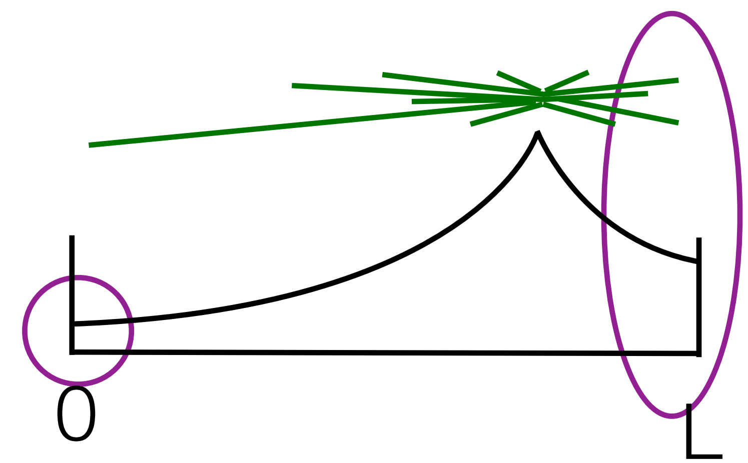

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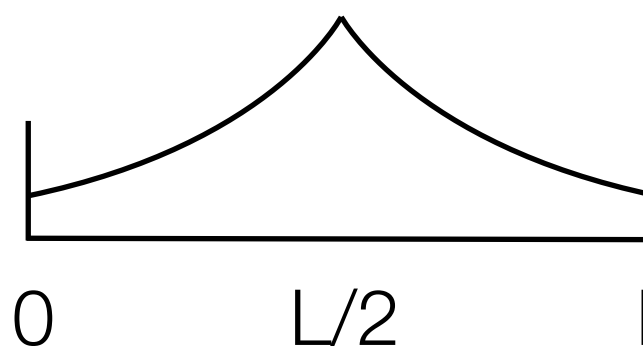

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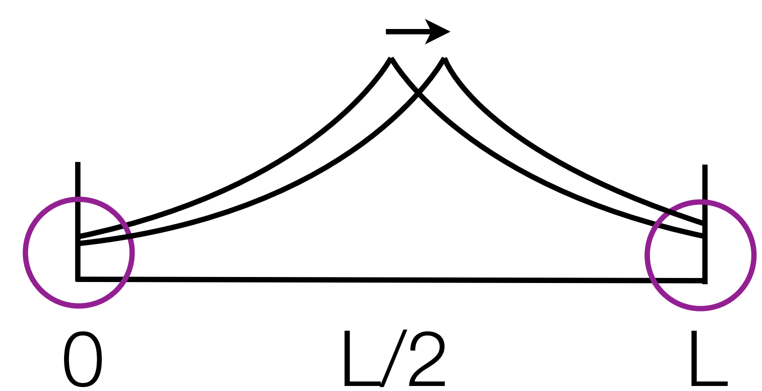

$$F'_{pull}(L/2) = B\lambda(e^{-\lambda L/2} + e^{-\lambda L/2}) > 0$$

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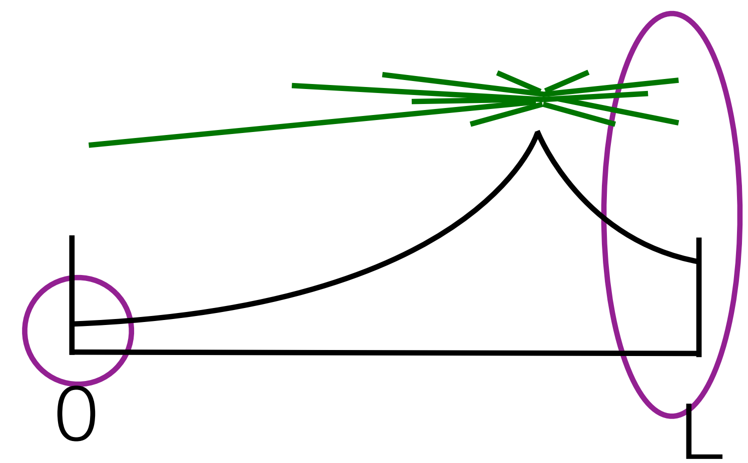

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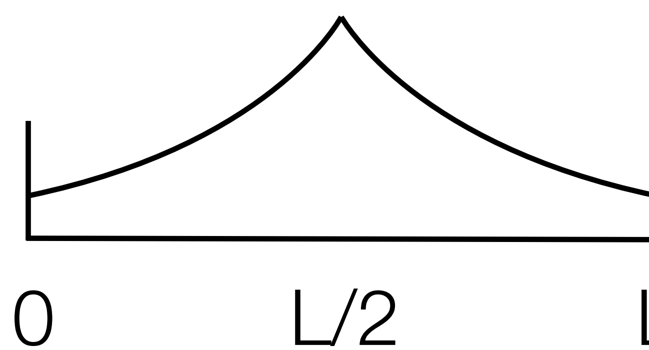

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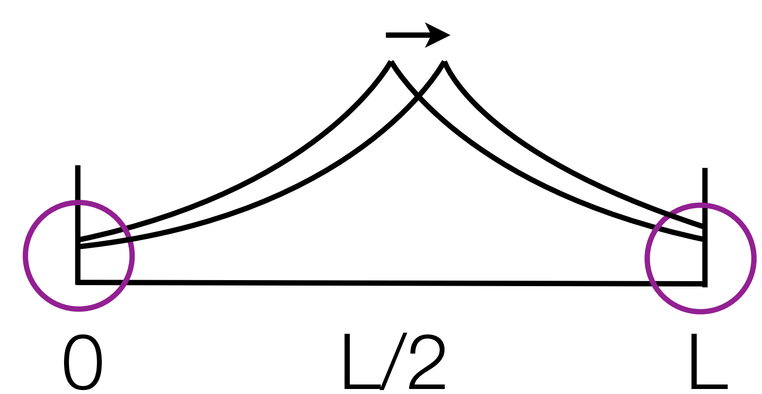

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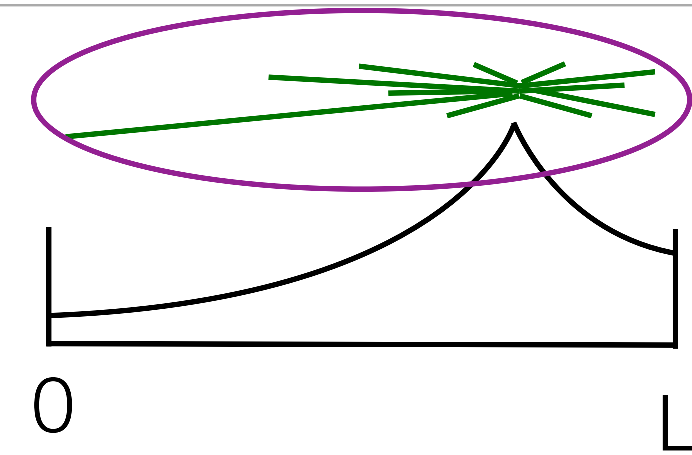
Center is unstable!

One-D model - calculating forces from MT densities



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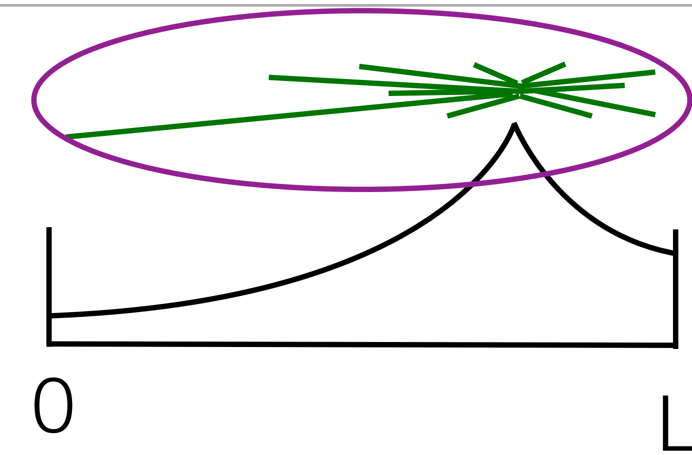

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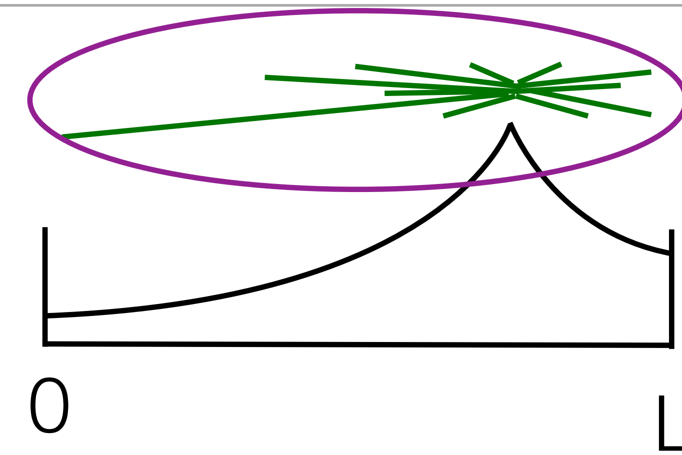

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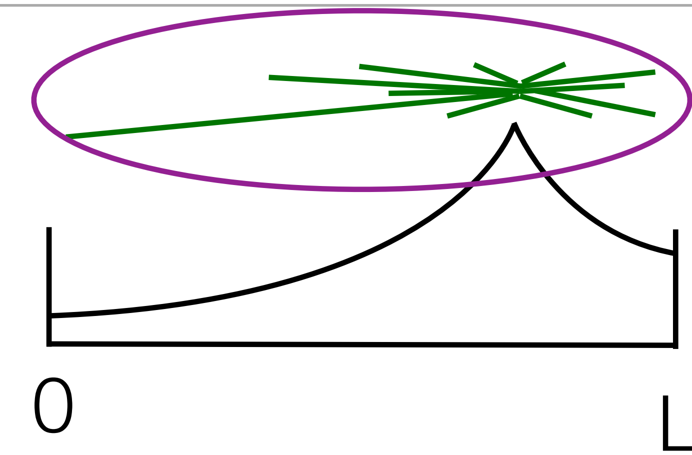

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