Direct observation of kinesin stepping by optical trapping interferometry

Karel Svoboda, Christoph F. Schmidt, Bruce J. Schnapp, Be Steven M. Block

StatPhy IV

06.03.2025

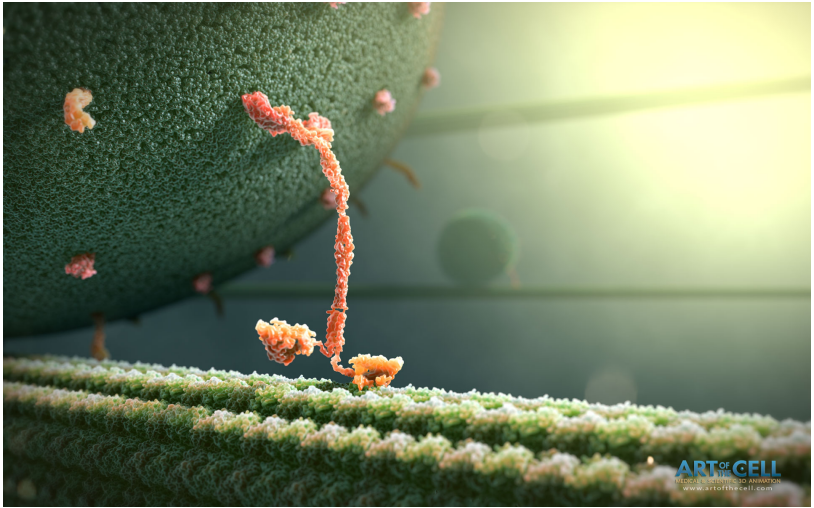
Table of Contents

Motivation

Do biological motors move with regular steps?

- are there even steps?
- is the movement continuous or discontinuous?
- is the stepsize constant?

Kinesin walking



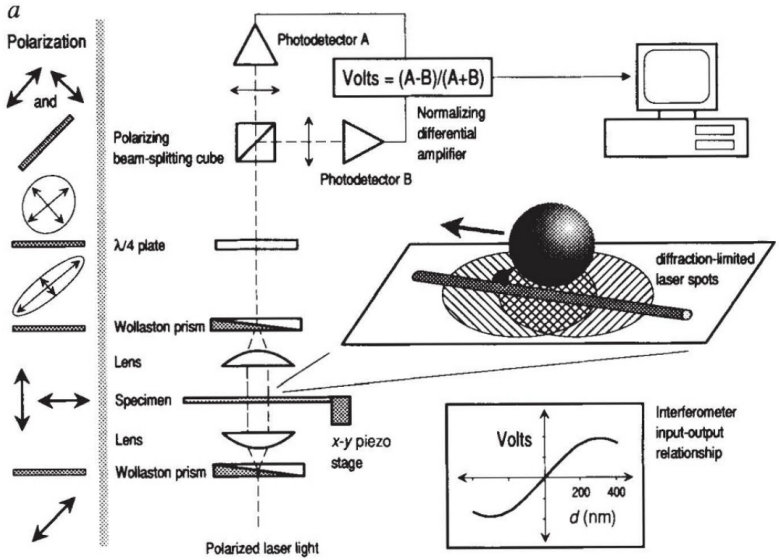
https://www.artofthecell.com/well-you-can-tell-by-the-way-i-use-my-walk/

Silica beads

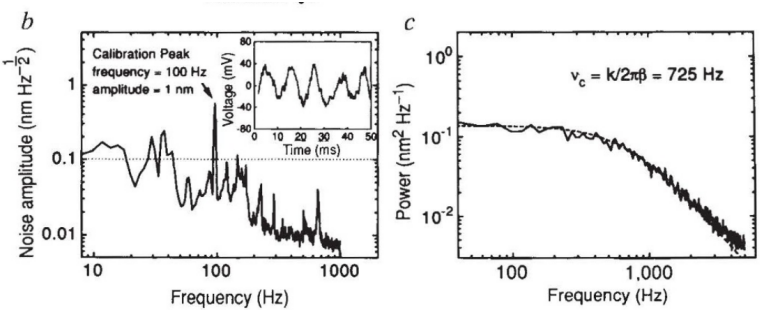
[1]

[1] reference: https://www.healthline.com/health/digestive-health/what-happens-if-you-eat-silica-gel

Optical trapping interferometer



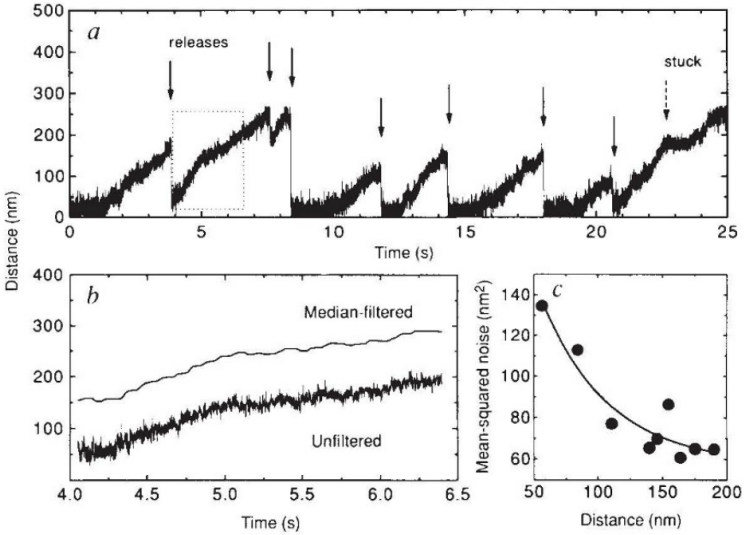
Calibration of the noise and force



b. Spectral noise density of signal and noise

c. Force calibration to find k

Measurement in the time domain



Three regimes for experiment

Low-load regime

$P = 17mW \rightarrow$ trapping force linear: $F = 0pN$ (middle) to $F = 1.5pN$ (edge detector zone)
ATP concentration $c = 10\mu M$

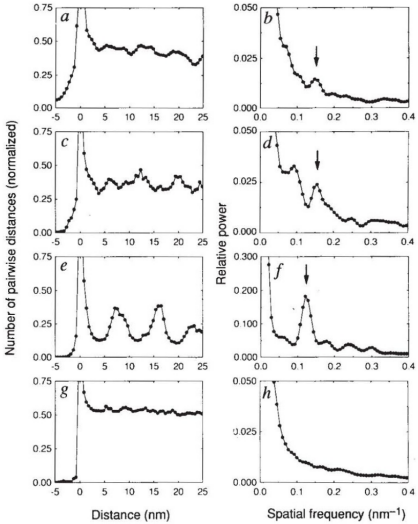
High-load regime

$P = 58mW \rightarrow$ trapping force linear: $F = 0pN$ (middle) to $F = 5pN$ (edge detector zone)
ATP concentration $c = 500\mu M$ (saturation level)

Low-ATP regime

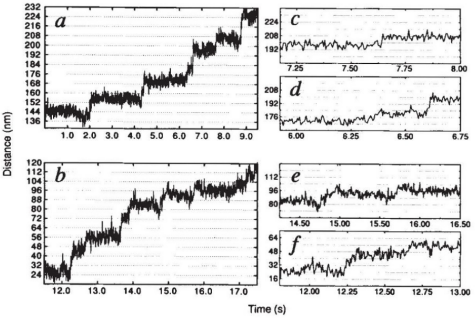
$P = 17mW \rightarrow$ trapping force linear: $F = 0pN$ (middle) to $F = 1.5pN$ (edge detector zone)
ATP concentration $c = 1$ or $2\mu M$

Low-load regime



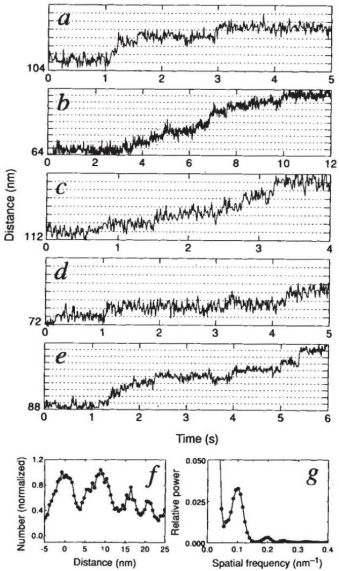
- Bin width $= 0.5nm$
- Left column: pairwise distribution function (PDF)
- Right column: FFT of PDF, averaged for 17 records from 10 diff. beads
- periodicity $6.7 \pm 0.2nm$

High-load regime



- $8 \pm 2nm$ from time trace for small steps
- double steps $17nm$

Low-ATP regime



- 10-point jumping average for data taken at $1kHz$
- periodicity $8.8 \pm 0.5nm$