Moving as one?
Collective steps in molecular motor assemblies

J.-F. Rupprecht[a*], J. Prost[a,b], M. P. Sheetz [a,c].

a. Mechanobiology Institute, National University of Singapore, 5A Engineering Drive 1, 117411 (Singapore).
b. Laboratoire Physico Chimie Curie, Institut Curie, PSL Research University, CNRS UMR168, 75005 Paris, France.
c. Department of Biological Sciences, Columbia University, New York, New York 10027, USA.

∗ mbijr@nus.edu.sg

Cells sense the rigidity of their environment through local pinching – just as you would do with your finger and thumb when you want to know if something is soft or rough. Such rigidity sensing is perturbed in most cancer cells, which spread and grow on soft environment – while normal cell would not.

Healthy cells rely on myosin II motor assemblies – which contract over bundles of polymers called actin – to pinch their environment. Recent high resolution experiments performed on such myosin assemblies are challenging the current understanding of molecular motor force generation [1]. These experiments show that:
(1) myosin II motors are surprisingly efficient, exerting forces an order of magnitude larger than the commonly accepted 3pN/motor value obtained through in vitro experiments, and
(2) that the actomyosin contractions occur through 2.5nm steps, which correspond to half of the actin period (5nm).

By developing a new look on a molecular motor toy model, called two-state model [2], we show that we can explain both experimental observations. In particular, we explain why efficient motors necessarily contract in a step-wise fashion, with 2.5nm steps, while weak motors do not exhibit such steps - thus rationalizing the specificity of motor contractions implied in rigidity-sensing compared to previous in vitro observations.

[1] J. Lohner, J.-F. Rupprecht, Junquiang Hu, N. Mandriota, M. Saxena, J. Hone, D. Pitta de Araujo, O. Sahin, J. Prost, M. Sheetz, bioRxiv https://doi.org/10.1101/296400

[2] F. Julicher, A. Ajdari, J. Prost, *Modeling molecular motors*. Reviews of Modern Physics, **69**, 4 (1997).