Multiscale motility of molecular motors: From single motor molecules to cooperative cargo transport

Reinhard Lipowsky

MPI of Colloids and Interfaces, Dept of Theory and Bio-Systems, Science Park Golm, 14424 Potsdam, Germany

Within all eukaryotic cells, including those of our body, we encounter heavy traffic of cargo particles such as vesicles, organelles, or filaments. The associated cargo transport covers mesoscopic or even macroscopic distances and is performed by teams of molecular motors, which make discrete nanometer steps along cytoskeletal filaments.

During the last decade, we have developed a multiscale approach, by which one can understand the cooperative behavior of these motors [1,2] in terms of their single motor properties [3]. Here, I will focus on three issues that have been recently addressed within this general framework:

(i) The free energy transduction and kinetics of a single team of two identical motors that are elastically coupled via their common cargo. The corresponding stochastic process explores a complex chemomechanical network but involves only two additional parameters apart from the single motor properties [4];

(ii) The different transport regimes for such a single motor team. These regimes exhibit different forms of motor-motor interference and arise from the competition between spontaneous unbinding, mutual strain-induced unbinding, and mutual strain-induced stalling of the motors [5]; and

(iii) The cooperative transport by two teams of molecular motors, a slow and a fast team that differ in their transport velocity [6].

In all cases, our theories are in good agreement with available experimental data and make predictions that are accessible to future experiments.

[1] M. J. I. Müller, S. Klumpp, and R. Lipowsky, PNAS 105, 4609 (2008)

[2] R. Lipowsky, J. Beeg, R. Dimova, S. Klumpp, and M. J. I. Müller, Physica E 42, 649 (2010)

[3] R. Lipowsky, S. Liepelt, and A. Valleriani, J. Stat. Phys. 135, 951 (2009)

[4] C. Keller, F. Berger, S. Liepelt, and R. Lipowsky, J. Stat. Phys. 150, 205 (2013)

[5] F. Berger, C. Keller, S. Klumpp, and R. Lipowsky, Phys. Rev. Lett. 108, 208101 (2012)

[6] Xin Li, R. Lipowsky, and J. Kierfeld, Biophys. J. 104, 666 (2013)