

## RED BLOOD CELL MECHANICS AND MEMBRANE FLUCTUATIONS: PASSIVE VERSUS ACTIVE

Dmitry A. Fedosov<sup>1\*</sup>, Timo Betz<sup>2</sup>, Herve Turlier<sup>2</sup>, Thorsten Auth<sup>1</sup>, Nir Gov<sup>3</sup>,  
Cecile Sykes<sup>2</sup>, Jacques Prost<sup>2</sup>, Jean-Francois Joanny<sup>2</sup>, and Gerhard  
Gompper<sup>1</sup>

<sup>1</sup> Institute of Complex Systems and Institute for Advanced Simulation, Forschungszentrum  
Jülich, 52425, Jülich, Germany

<sup>2</sup> Institut Curie, Section de recherche, UMR 168, Paris, France

<sup>3</sup> Department of Chemical Physics, The Weizmann Institute of Science, P.O.B. 26, Rehovot,  
Israel 76100

\* Corresponding author, e-mail: d.fedosov@fz-juelich.de

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Red blood cells (RBCs) are soft and flexible biconcave discs, which are able to pass through capillaries with diameters several times smaller than the RBC size. The RBC deformability also results in noticeable membrane fluctuations, which must be correlated with RBC membrane properties. However, it is still under debate whether RBC membrane fluctuations are simply passive thermal undulations or whether a red cell also experiences active fluctuations which are driven by a metabolic activity or other cell processes. We will present direct evidence that the RBC undulations are not solely passive thermal fluctuations, which has been obtained from a set of different experiments, simulations, and theory. Experimental results show a violation of the fluctuation-dissipation theorem (FDT) for freshly prepared RBCs indicating the existence of active processes. However, the FDT is satisfied for starved cells demonstrating that the membrane fluctuations are passive when the energy supply is absent. Experiments also show a considerable change in the fluctuation amplitudes for fresh and starved cells. Subsequently, we perform simulations which fully mimic and quantify the experiments. We are able to quantitatively extract RBC membrane properties including shear elasticity, bending rigidity, and membrane viscosity. Furthermore, we test several models for active fluctuations, which mimic different possible mechanisms including spectrin network remodeling, ion pumps, and change in the spontaneous membrane curvature. Simulation results agree well with experimental data and suggest that several processes mentioned above may contribute to active RBC fluctuations. We will discuss which processes are more likely to take place.