

"Biomolecules in Thermal Fields"

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Life signals most of its information by the interaction of molecules. It is important to quantify both the interaction strength and the reaction speed to understand the detailed function of biological reaction networks. Methods are still lacking to measure both in complex biological liquids such as blood serum or cell lysate.

We found that the movement of proteins in a temperature gradient is a sensitive and versatile way to probe protein interactions, including the important class of membrane receptors binding to its target molecule. The binding was detected all-optically in various biological fluids. We screened for drug-protein interactions without labeling the protein and were able to successfully commercialize the method. The physical basis of the movement was studied with DNA and polystyrene beads and could be understood with a capacitor model of ionic shielding.

We managed to measure the reaction speed inside living cells using fast temperature oscillations and a molecular lock-in method. Maps of the reaction speed reveal both faster and slower reactions as compared to outside the cell. This indicates a complex kinetic control of cellular reactions.

Thermal fields not only move molecules. A spatially moving warm spot moves water all-optically along arbitrary paths, opening the possibility of light driven microfluidics. Thermal expansion in a viscosity gradient explains this nonlinear effect. Combined with the thermal control of molecules, various molecule traps can be implemented.

Thermal molecule traps occur naturally in hydrothermal pores of rock. They offer a compelling disequilibrium system to drive molecular evolution. In such settings, we experimentally demonstrate basic replication using tRNA and show a Darwinian process, i.e. DNA replication and selection.