MAR13-2012-020847

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Biophysical Variables Which Are Available from Single-Molecule Optical Studies[1]

W.E. MOERNER, Stanford University

Since the first optical detection and spectroscopy of a single molecule in a condensed phase host in 1989, a wealth of new information has been obtained from time-dependent measurements and single-molecule probability distributions. When single-molecule imaging is combined with active control of the emitter concentration, enhanced spatial resolution well beyond the optical diffraction limit can be obtained for a wide array of biophysical structures in cells. Single-molecule emitters also provide precise and accurate 3D position as well as dipole moment orientation when combined with Fourier plane processing. Examples here include the implementation of a double-helix point spread function for 3D position information (Backlund, Lew et al. PNAS (2012)), and the creation of a quadrated pupil response to sense emission dipole orientations (Backer et al. submitted 2012). If high-resolution spatial information is not needed, a machine called the Anti-Brownian ELectrokinetic (ABEL) trap provides real-time suppression of Brownian motion for single molecules in solution for extended analysis of dynamical state changes (Wang et al. Acc. Chem. Res. (2012)). With proper design of reporter fluorophore, individual electron transfer events to a single Cu atom in a redox enzyme may be sensed under turnover conditions (Goldsmith et al. PNAS (2011)). Optical counting of fluorescent ATP nucleotides on a multisubunit enzyme provides measurement of ATP number distributions, which can be used to generate a new window into enzyme cooperativity devoid of ensemble averaging (Jiang et al PNAS (2011)). With advanced control system design of feedback to enable optimal trapping performance, the ABEL trap also allows direct, simultaneous measurement of three variables: brightness, excited state lifetime, and emission spectrum, for objects as small as individual $\sim$1-2 nm sized fluorophores in solution (Wang et al. JPCB (in press 2013)). These examples illustrate some of the wide variety of physical variables which may now be measured for single molecules in a various condensed phase environments ranging from aqueous solutions to living cells.

[1]Work supported by NIGMS and DOE-BES