BiophysTO Lunchtime Seminar Series

Date
Thursday, March 18, 2021
12:00 – 1:00 pm

Location
Virtual via zoom

Dr. R. J. Dwayne Miller

Departments of Chemistry and Physics
University of Toronto

Fundamental Space-Time Limits to Imaging Chemistry and Biology: Towards Making a Molecular Map of the Cell

One of the long-sought objectives in science has been to watch atomic motions on the primary timescales governing structural transitions. From a chemistry perspective, this capability would give a direct observation of reaction forces and probe the central unifying concept of transition states that links chemistry to biology. To achieve this objective, there are not only extraordinary requirements for simultaneous spatial-temporal resolution but equally important, due to sample limitations, also one on source brightness. With the development of ultrabright electrons capable of literally lighting up atomic motions, this experiment has been realized (Siwick et al Science 2003) and efforts accelerated with the onset of XFELs (Miller, Science 2014). The table-top ultrabright electron sources developed at the University of Toronto have achieved the fundamental space-time limit to imaging chemistry (Li et al, ACS Photonics 2020). A number of fully atomically resolved chemical reactions will be discussed. These studies have discovered that these high dimensional problems, order 3N (N number of atoms in the reaction volume) representing the number of degrees of freedom in the system, distilled down to atomic projections along a few principle reaction coordinates. This enormous reduction in dimensionality appears to be general, arising from the very strong anharmonicity of the many body potential in the barrier crossing region. The "magic of chemistry" is this enormous reduction in dimensionality at the barrier crossing that ultimately makes chemical concepts transferrable and allowed scaling in complexity all the way to living systems. Given the enormous complexity in terms of coupled chemical reactions driving biological processes within cells there must be a similar reduction principle at play. We currently can only report static structures and functions by spatial association. We have no information on the spatial gradients in free energy within the cell that ultimately turn genes on or off, lead to mutable responses to environmental changes etc., as part of living systems' response functions. The same technology developed to directly observe atomic motions can be adapted to next generation spatial imaging modalities, along with correlative imaging, to directly map the chemical driving forces of the cell. This prospect promises to fill in the gaps between genetic information and protein expression, from the blueprint to the actual execution of the code. The specific technological requirements under development to achieve this Moonshot for Biology and their potential spin off applications will be discussed as part of proposal for a Strategic Initiative to Map the Cell.

Host: Dr. Walid A. Houry

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