The Sir Martin Wood Prize Lecture

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Theory of Real-time Quantum Dissipative Dynamics and its Application to Photosynthetic Light Harvesting Systems

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Biography

2008 D.Sc. Kyoto University

2006 JSPS Research Fellow, Kyoto University

2008 JSPS Postdoctoral Fellow for Research Abroad, University of California, Berkeley

2010 Postdoctoral Fellow, Lawrence Berkeley National Laboratory

2012 Research Associate Professor, Institute for Molecular Science

2013 Fellow 2012–2013, Wissenschaftskolleg zu Berlin

2016 Professor, Institute for Molecular Science

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Martin Wood Lecture Theatre
Department of Physics
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Quantum dynamic phenomena are ubiquitous in molecular processes, and yet remain a challenge for experimental and theoretical investigations. On the experimental side, it has become possible to explore molecular processes on a timescale down to a few femtoseconds by means of ultrashort laser pulses. This progress in ultrafast laser spectroscopy has opened up real-time observation of dynamic processes in complex chemical and biological systems, and has provided a strong impetus to theoretical studies of condensed phase quantum dynamics or real-time quantum dissipative dynamics.

Investigation on the primary steps of photosynthesis is an example of such efforts. With minor possible exceptions near hydrothermal vents, this process provides the energy source for essentially all living things on Earth. Photosynthetic conversion of the energy of sunlight into its chemical form suitable for cellular processes involves a variety of physicochemical mechanisms. The conversion starts with the absorption of a photon of sunlight by one of the light-harvesting pigments, followed by transfer of electronic excitation energy to the reaction center. At low light intensities, the quantum efficiency of the conversion is near unity; that is, each of the absorbed photons almost certainly reaches the reaction center and drives the electron transfer reactions. A longstanding question in photosynthetic research has been the following: How do light-harvesting systems deliver such high efficiency in the presence of disordered and fluctuating dissipative environments? The precise molecular mechanisms are not yet fully elucidated from the standpoint of physical sciences.

In this presentation, we provide an overview of recent experimental and theoretical investigations of photosynthetic energy/charge transfer, specifically addressing interplays between quantum mechanical effects and dynamic fluctuations of pigments' electronic states induced by their surrounding proteins.

Professor Ishizaki was awarded the Sir Martin Wood Prize at the Millennium Science Forum which took place at the British Embassy, Tokyo in November 2016. The Millennium Science Forum was established in 1998 to promote scientific exchange between Britain and Japan and recognize the work of outstanding young Japanese researchers. The prize is named after Sir Martin Wood, Founder of Oxford Instruments.

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