## Discussion leader


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## Introductory Talk – Many-Body Physics: The Holy Grail of Modern Sciences and Technologies


### Abstract

The quantum many-body problem is at the heart of a variety of physical and chemical functionalities in our real world ranging from the emergence of superconductivity and magnetism in solid materials to the interaction of drug molecules with their targets in a liquid. Addressing quantum many-body problems is thus one of the holy grails of modern sciences and technologies. It is extremely hard, however, to solve such quantum many-body problems in those strongly-correlated systems with the current silicon-based computers. In solving the Hubbard model, for example, by the exact diagonalization to obtain its stationary eigenstates, it is effectively impossible to handle more than 30 particles even with the "post-K" supercomputer planned to be completed in 2020 in Japan. If the number of particles were 1000, the diagonalization would take $10^{126}$ years. Moreover, in order to control those functionalities with external fields such as light, it is important to predict nonstationary evolutions (dynamics) induced by the external fields as well as the stationary eigenstates. It is, however, by far more demanding to calculate the dynamics of the quantum many-body system than its stationary states. Studies on such many-body dynamics should allow us to better understand and control the emergence of the macroscopic physical and chemical functionalities. Recently, atomic, molecular, and optical physics with advanced photonics is rapidly emerging as a new platform to study quantum many-body systems. One of its latest developments is the study of long-range interactions among ultracold particles such as magnetic atoms, polar molecules, ions, and Rydberg atoms, whose temperatures are close to absolute zero. These studies could lead to even new quantum technologies, in which atomic and molecular crystals assembled in optical traps develop into a novel simulation platform for the design of functional matter such as superconducting and magnetic materials and drug molecules, replacing the current simulation tools based on silicon-based supercomputers in the future. In this symposium, we will discuss the cutting edge of this new frontier of many-body sciences and technologies and its future perspectives.

I would also like to introduce our recent study on strongly correlated Rydberg atoms, in which we combine ultrafast coherent control [1] and ultracold physics to observe and manipulate quantum many-body dynamics on the ultrafast timescale [2].


### References


[1] See, for example, K. Ohmori, Annu. Rev. Phys. Chem. **60**, 487-511 (2009) and references therein; H. Katsuki et al., Phys. Rev. Lett., **102**, 103602 (2009); K. Hosaka et al., Phys. Rev. Lett. **104**, 180501 (2010); H. Goto et al., Nature Phys. **7**, 383-385 (2011); H. Katsuki et al., Nature Commun. **4**, 2801 (2013).

[2] N. Takei et al., arXiv: 1504.03635 (2015).


### About the Author

Kenji Ohmori is a Professor at the Institute for Molecular Science (IMS) of the National Institutes of Natural Sciences in Okazaki, Japan, where he is also the Chairman of the Department of Photo-Molecular Science. After receiving his Ph.D. from The University of Tokyo in 1992, he was a Research Associate and an Associate Professor at Tohoku University. In 2003 he was appointed a Full Professor at IMS. His research interests focus on exploring the quantum-classical boundary and developing quantum technology based on the wave nature of matter. He has been honored with the Japan Academy Medal (2007), JSPS Prize (2007), is a Fellow of the American Physical Society (2009), and has received the Humboldt Research Award (2012).