Ultrafast quantum simulator with attosecond precision at ultracold temperatures

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Many-body correlations govern a variety of important quantum phenomena including the emergence of superconductivity and magnetism in condensed matter as well as chemical reactions in liquids. Understanding quantum many-body systems is thus one of the central goals of modern sciences and technologies. Here we demonstrate a new pathway towards this goal by generating a strongly correlated ultracold Rydberg gas with a broadband ultrashort laser pulse. We have applied our ultrafast coherent control with attosecond precision [1] to a strongly correlated Rydberg gas in an optical dipole trap, and have successfully observed and controlled its ultrafast many-body electron dynamics [2-4]. This new approach is now applied to an atomic BEC, Mott insulator lattice, and arbitrary array assembled with optical tweezers to develop into a pathbreaking platform for quantum simulation of strongly correlated many-body electron dynamics on the ultrafast timescale [5-7].

This project is in progress in tight collaboration with Hamamatsu Photonics K.K.

References

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[7] UC Boulder / NIST Quantum Technology Website : CUbit Quantum Initiative https://www.colorado.edu/initiative/cubit/newsletter/newsletter/june-2020 "A metal-like quantum gas: A pathbreaking platform for quantum simulation"