世纪物理情·系列讲座

Fast single-shot imaging of individual ions and Rydberg superatoms via long-range interactions

【报告人】

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【 时间 】

2024/ 03 / 20（周三）

下午 4:00

【 地点 】

清华大学高等研究院

科学馆104报告厅

【摘要】

Rydberg atoms have recently emerged as a prominent platform for developing various quantum technologies, including quantum simulation and computation, quantum nonlinear conversion, quantum sensing. The essential element enabling the high degree of control and manipulation at the single-particle level in these systems is the strong long-range interaction between Rydberg atoms. The resulting excitation blockade effect is an important resource for quantum applications.

More specifically, Rydberg energy levels of atoms are genuinely sensitive to van der Waals and dipole-charge interactions, which scale with principal quantum number n as n^{11} and n^{7} and with distance r as $1/r^{6}$ and $1/r^{4}$, respectively. In the dissipative regime, capitalizing on the scattering effect induced by these long-range interactions, we employ electromagnetically induced transparency for fast in-situ imaging of individual ions and Rydberg superatoms in a single shot with an exposure time on the order of ~1 μs. Such sensitivity is reached by making use of homodyne detection and amplification of Van der Waals interactions in the proximity of molecular Förster resonances. With this technique, we resolve a linear chain of Rydberg superatoms excited in a one-dimensional configuration. Pair-correlation and Fourier analyses of the images reveal the effect of the dipole blockade and long-range ordering of Rydberg excitations. This imaging technique with minimal destruction will be of great interest for utilizing ensemble-encoded Rydberg qubits for quantum computation and quantum simulation.

References

[1] C. Gross, T. Vogt, and W. Li, Ion Imaging via Long-Range Interaction with Rydberg Atoms, Phys. Rev. Lett. 124, 053401 (2020)

[2] D. Jinjin, T. Vogt, and W. Li, Fast Single-shot Imaging of Individual Ions via Homodyne Detection of Rydberg Blockade Induced Absorption, Phys. Rev. Lett. 130, 143004 (2023).

【报告人简介】

Dr. Wenhui Li is a professor at the Institute of Opto-Elctronics, Shanxi University. After graduating from Fudan Univesity, she went to the University of Virginia to pursue her PhD study in the field of cold Rydberg gases. Upon the completion of PhD degree in 2005, she worked as a postdoctoral researcher at Rice University on strongly interacting degenerate Fermi gases. In 2009, she joined the Center for Quantum Technologies at the National University of Singapore as a principal investigator and had since then led a research group there to investigate Rydberg physics. She moved to the current position in 2023. Her recent research interests include quantum measurement, quantum nonlinear process, and quantum simulation based on Rydberg atoms.

主办单位:清华大学高等研究院