δ-quench measurement of a pure quantum-state wavefunction

With the support by the National Natural Science Foundation of China, the research team collaborated by Profs. Zhang ShanChao (张善超), Yan Hui, and Zhu ShiLiang at the Guangdong Provincial Key Laboratory of Quantum Engineering and Quantum Materials, School of Physics and Telecommunication Engineering, South China Normal University (SCNU) and Prof. Shengwang Du at the Department of Physics, Hong Kong University of Science Technology (HKUST), theoretically propose a new type of versatile strategy for quantum wavefunction measurement, the δ-quench measurement method. With the new method the measurement of photon's temporal quantum wavefunction is experimentally demonstrated. The relevant research results were published in *Physical Review Letters* (2019, 123: 190402)

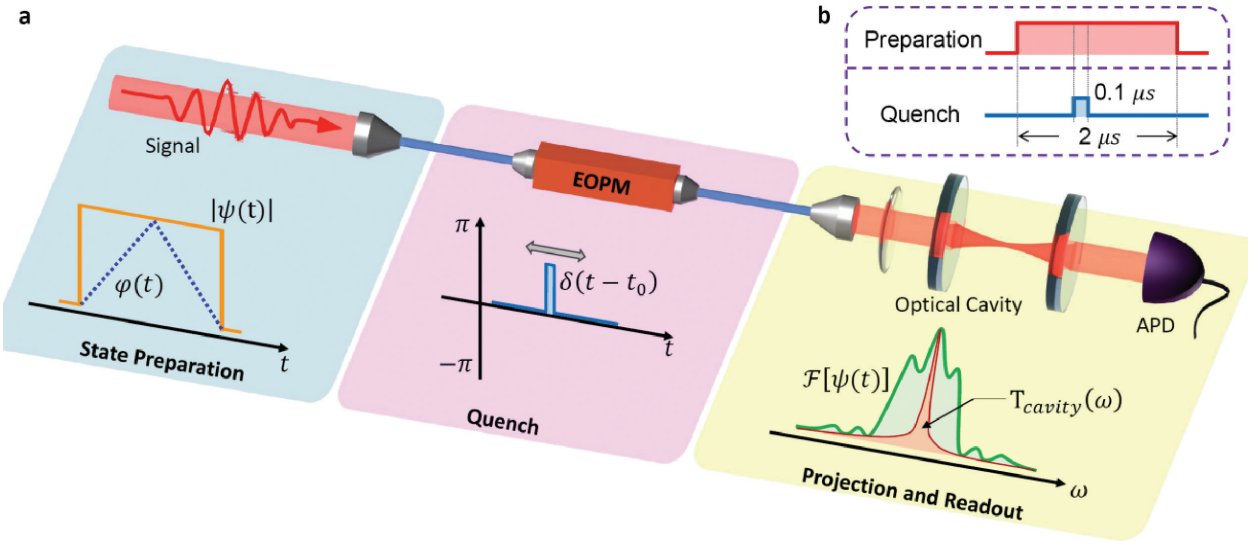

Figure Experimental setup of delta quench measurement of photon's temporal quantum wavefunction.

In the development of modern science, occurrence of new measurement methods may bring researchers new ideas and new observations and then the progress of scientific research field. In quantum physics, measuring quantum state wavefunction not only acts as a fundamental part but also plays an important role in developing practical quantum technologies. Conventional quantum state tomography has been widely used to estimate quantum wavefunctions, which usually requires complicated measurement techniques. The recent weak-value-based quantum measurement brings us a strategy of directly measuring the quantum state but it relies on an extra pointer space.

The joint team from SCNU and HKUST develop and demonstrate a direct and efficient measurement strategy based on δ-quench probe: For an unknown pure quantum state, one can quench it by varying one of its complex probability amplitudes in a measurement Hilbert space and then project the quenched state onto a post-selection state that is non-orthogonal to all the bases in the measurement space. The real and imaginary components of its quantum wavefunction can be directly obtained from the sequentially measured quench-dependent responses. This δ-quench measurement is experimentally realized in measuring photonic complex temporal wavefunctions, which verifies that this method is robust and efficient with limited measurement resources. This new method is versatile and can find applications in quantum information science and engineering.