**Quantum noise squeezing, wavefunction reconstruction, and it’s applications**

Ray-Kuang Lee

Institute of Photonics Technologies, National Tsing-Hua University, Hsinchu City 300, Taiwan

Even though a quantum state, as well as its wavefunction, is a mathematical entity in quantum physics, the knowledge of the quantum state makes the quantum information science accessible. Based on the Wigner function in phase space [1], we report our implementation of squeezed vacuum states at 1064 nm, with the noise reduction up to 10dB below the vacuum fluctuations. Based on the convolutional neural network (CNN) used in machine learning [2], we demonstrate experimentally a fast reconstruction of quantum wavefunction and the corresponding density matrix elements for continuous variables quantum states. In addition to the measurement scheme based on our home-made balanced homodyne detectors, the weak measurement theory can also provide an alternative approach to enhance the measured values [3]. As the true applications, the injection of our squeezed vacuum state into the future gravitational-wave detectors has proven to be an effective strategy to break the quantum noise limit in the detector sensitivity [4].

[1] Popo Yang, Ivan F. Valtierra, Andrei B. Klimov, Shin-Tza Wu, RKL, and Luis L. Sanchez-Soto, and Gerd Leuchs, "The Wigner flow on the sphere," Physica Scripta 94, 044001 (2019); for the New Focus issue: Quantum Optics and Beyond- in honour of Wolfgang Schleich.

[2] Alexey A. Melonikov, Leonid E. Fedichkin, RKL, and Alexander Alodjants, "Machine learning transfer efficiencies for noisy quantum walks," Adv. Quant. Tech. 3,1900115 (2020); also selected as the Back Cover for Adv. Quant. Tech. April issue (2020).

[3] Minyi Huang, RKL, Lijian Zhang, Shao-Ming Fei, and Junde Wu, "Simulating broken PT-symmetric Hamiltonian systems by weak measurement," Phys. Rev. Lett. 123, 080404 (2019).

[4] Yuhang Zhao et al., "Frequency-dependent squeezed vacuum source for broadband quantum noise reduction in advanced gravitational-wave detectors," Phys. Rev. Lett. 124, 171101 (2020); Editors' Suggestion; Featured in Physics.