**Quantum Optics with Machine-Learning: Introduction to Machine-Learning enhanced Quantum State Tomography**

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With this webinar, I shall be covering fundamental details about machine-learning (ML) enhanced quantum state tomography (QST) for squeezed states. Implementation of machine learning architecture with a convolutional neural network will be illustrated and demonstrated through the experimentally measured data generated from squeezed vacuum states [1]. In addition to using the reconstruction model in training a truncated density matrix, we also develop a high-performance, lightweight, and easy-to-install supervised characteristic model by generating the target parameters directly [2]. With the help of machine learning-enhanced quantum state tomography, we also experimentally reconstructed the Wigner’s quantum phase current for the first time [3]. A brief view on quantum ML will also be discussed [4]. At the same time, as a collaborator for LIGO-Virgo-KAGRA gravitational wave network and Einstein Telescope, I will introduce our plan to inject this squeezed vacuum field into the advanced gravitational wave detectors [5]. I will also cover progress in applying such a ML- QST as a crucial diagnostic toolbox for applications with squeezed states, from quantum information process, quantum metrology, and macroscopic quantum state generation.

**References**

[1] Hsien-Yi Hsieh, et al., "Extract the Degradation Information in Squeezed States with Machine Learning," Phys. Rev. Lett. 128, 073604 (2022).

[2] Hsien-Yi Hsieh, et al., "Direct parameter estimations from machine-learning enhanced quantum state tomography," Special Issue "Quantum Optimization & Machine Learning"; Symmetry 14, 874 (2022).

[3] Yi-Ru Chen, et al., "Experimental Reconstruction of Wigner Distribution Currents in Quantum Phase Space," [arXiv: 2111.08285].

[4] Alexey Melnikov, Mohammad Kordzanganeh, Alexander Alodjants, and Ray-Kuang Lee, "Quantum Machine Learning: from physics to software engineering," invited Review Article for Advances in Physics X (2022).

[5] 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.