

Research Result Report

ICRR Inter-University Research Program 2025

Research Subject: Filter cavity experiments for the frequency dependent squeezed light for KAGRA
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Summary of Research Result : With ICRR and NAOJ, in this ICRR Inter-University Research Program 2025, entitled “Filter cavity experiments for the frequency dependent squeezed light for KAGRA,” we worked with the KAGRA Filter Cavity (KFC) working group. The target is to implement a SQUEEZER to upgrade the sensitivity of KAGRA. From KAGRA Filter Cavity Team (KFC) to KAGRA Squeezing Subsystem (SQZ) The specific outcome of this proposal is to be able to quickly characterize quantum noise squeezing spectra produced at the TAMA facility. Fast characterization would then unlock future avenues in quantum state control and manipulation. The first part involves preparing the system for collecting optimal training data. We must feed well-characterized squeezing spectra or time domain signals into the machine learning model. An end goal would be to obtain a series of estimates of degradation parameters with a high-resolution variation of mode mismatch. At the same time, our home-made vOPO has been delivered to NAOJ for the testing in the vacuum environment, see Fig. 1.1. Further setup on the squeezing generation, measurement, and characterization will also be needed. The follow-up setups include the vacuum chamber, suspension, isolation, and control systems.

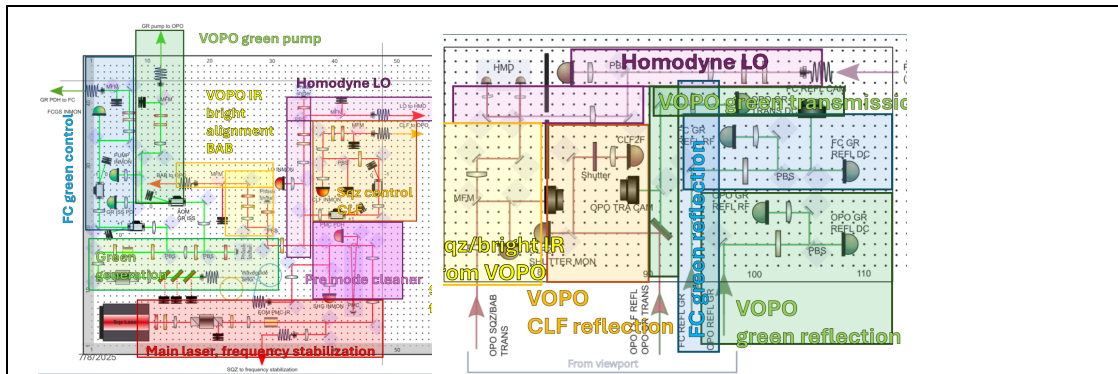


Fig. 1.1: The experimental layout of squeezer in TAMA 300 interferometry (courtesy: Michael Page).

FY2025, and published 2 papers with ICRR acknowledged.

[1] Hsun-Chung Wu, Hsien-Yi Hsieh, Zhi-Kai Xu, Hua Li Chen, Zi-Hao Shi, Po-Han Wang, Popo Yang, Ole Steuernagel, Te-Hwei Suen, Chien-Ming Wu, and RKL, "Machine learning enhanced quantum state tomography on a field-programmable gate array," APL Quantum 2, 026117 (2025); Cover; Featured Article; Scilight.

[2] Juan Camilo Rodríguez, Hsien-Yi Hsieh, Hua-Li Chen, Ole Steuernagel, Chien-Ming Wu, and RKL, "Machine Learning for Quantum State Tomography: Robust Covariance Matrix Estimation for Squeezed Vacuum States with Thermal Noise," Opt. Express 33, 48876 (2025).

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