

Research Report

ICRR Inter-University Research Program 2022

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 2022, 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 this FDSQZ to upgrade the sensitivity of KAGRA. In addition to the bi-weekly telecons with the working group on the KAGRA Filter Cavity, in November 2022 and February 2023, our visits to the KAGRA F2F meeting in Kashiwa and to the 令和 4 年度東京大学宇宙線研共同利用研究成果発表会/Research Results Presentation Meeting of the ICRR Inter-University Research Program FY2022 were both supported by this project. Currently, we take the responsibility for the Interface Optics in the KFC working group, as well as the OPO design for the squeezer. In addition, we also received the Vanguard Project (for 4 years), entitled “Development on the Instrumentations and Data Analyses for Advanced Gravitational Wave Detectors,” from the Ministry of Science and Technology (MOST), Taiwan. At the same time, we developed about machine-learning (ML) enhanced quantum state tomography (QST) for squeezed states, as a crucial diagnostic toolbox for the

advanced gravitational wave detectors. Applications on the ML to frequency dependent squeezing (FDS) is also in progress. As listed below, we reported our research in the annual meeting of the ICRR Inter-University Research Program FY2022, and published 4 papers with ICRR acknowledged.

- Filter cavity experiments for the frequency dependent squeezed light for KAGRA, 令和 4 年度東京大学宇宙線研共同利用研究成果発表会/Research Results Presentation Meeting of the ICRR Inter-University Research Program FY2022
- Hsien-Yi Hsieh, Yi-Ru Chen, Hsun-Chung Wu, Hua Li Chen, Jingyu Ning, Yao-Chin Huang, Chien-Ming Wu, and RKL, "Extract the Degradation Information in Squeezed States with Machine Learning," Phys. Rev. Lett. 128, 073604 (2022).
- Hsien-Yi Hsieh, Jingyu Ning, Yi-Ru Chen, Hsun-Chung Wu, Hua Li Chen, Chien-Ming Wu, and RKL, "Direct parameter estimations from machine-learning enhanced quantum state tomography," Special Issue "Quantum Optimization & Machine Learning"; Symmetry 14, 874(2022).
- Yuhang Zhao, Eleonora Capocasa, Marc Eisenmann, Naoki Aritomi, Michael Page, Yuefan Guo, Eleonora Polini, Koji Arai, Yoichi Aso, Martin van Beuzekom, Yao-Chin Huang, RKL, Harald Luck, Osamu Miyakawa, Pierre Prat, Ayaka Shoda, Matteo Tacca, Ryutaro Takahashi, Henning Vahlbruch, Marco Vardaro, Chien-Ming Wu, Matteo Leonardi, Matteo Barsuglia, and Raffaele Flaminio, "Improving the stability of frequency dependent squeezing with bichromatic control of filter cavity length, alignment, and incident beam pointing," Phys. Rev. D 105, 082003 (2022).
- Naoki Aritomi, Yuhang Zhao, Eleonora Capocasa, Matteo Leonardi, Marc Eisenmann, Michael Page, Yuefan Guo, Eleonora Polini, Akihiro Tomura, Koji Arai, Yoichi Aso, Martin van Beuzekom, Yao-Chin Huang, RKL, Harald Luck, Osamu Miyakawa, Pierre Prat, Ayaka Shoda, Matteo Tacca, Ryutaro Takahashi, Henning Vahlbruch, Marco Vardaro, Chien-Ming Wu, Matteo Barsuglia, and Raffaele Flaminio, "Demonstration of length control for a filter cavity with coherent control sidebands," Phys. Rev. D 106, 102003 (2022).

In papers listed above, we added the supports by “The collaborative research program of the Institute for Cosmic Ray Research (ICRR), the University of Tokyo.” in the Acknowledgement.