Exploration of various magnon states using magnetization state tomography

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State tomography is one of the essential tools in quantum science to analyze the quantum and classical nature of arbitrary elementary excitations. Elementary excitations in magnetic materials include magnons (spin waves), and magnon dynamics and scattering processes determine various magnetic properties. Recently, magnon states characterized by unconventional fluctuations, such as squeezed states, mixed states, and entanglement between magnons, have been theoretically predicted and are being actively studied with a view to their application to quantum and nonclassical computation using magnetic materials. On the other hand, the state tomography for magnetization dynamics has yet to be developed, and there has been a limitation in investigating the magnon state.

In this talk, we propose and demonstrate a state tomography for magnetization dynamics that enables us to obtain the Wigner function, a probability distribution function that represents the fluctuation distribution of magnetization dynamics. Using an AC spin pump and a homodyne detection method, we experimentally realized the observation of magnon fluctuations and the reconstruction of the Wigner function. In this talk, I will introduce the experimental results of observing mixed magnon states using magnetization state tomography and show that it is possible to explore a new group of states focusing on magnon fluctuations. [Phys. Rev. B **104**, L100419 (2021), J. Appl. Phys. 132, 203901(2022)]

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