Low-energy Excitations in Multiferroics

T. Arima\textsuperscript{a,b,c}, H. Sagayama\textsuperscript{a}, K. Oizumi\textsuperscript{a}, N. D. Khanh\textsuperscript{a}, N. Abe\textsuperscript{a}, S. Ohira-Kawamura\textsuperscript{d}, T. Kikuchi\textsuperscript{d}, Y. Inamura\textsuperscript{d}, M. Nakamura\textsuperscript{d}, R. Kajimoto\textsuperscript{d}, K. Nakajima\textsuperscript{d}, M. Arai\textsuperscript{d}

\textsuperscript{a}Department of Advanced Materials Science, University of Tokyo, Kashiwa 270-8561, Japan
\textsuperscript{b}RIKEN SPring-8 Center, Hyogo 679-5148, Japan
\textsuperscript{c}RIKEN Center for Emergent Matter Science, Wako 351-0198, Japan
\textsuperscript{d}J-PARC Center, Ibaraki 319-1195, Japan

arima@k.u-tokyo.ac.jp

Since Kimura et al. discovered ferroelectricity and magnetic-field-induced 90-degree polarization rotation in a perovskite-type manganese oxide TbMnO\textsubscript{3} in 2003 [1], the spin-driven ferroelectricity has been a central topic in the correlated electron systems. Now there is a broad consensus that several types of magnetic order can produce ferroelectric polarization [2].

The coupling between the magnetism and electricity also gives rise to novel responses to electromagnetic waves. Pimenov and coworkers performed a terahertz time-domain spectroscopy in GdMnO\textsubscript{3} and TbMnO\textsubscript{3}, and found that a spin wave can be excited by an oscillating electric field in the spin-helix-driven ferroelectric phase [3]. Such an electrically-driven spin excitation is termed electromagnon. Now the presence of electromagnons has been reported in many frustrated magnets.

Takahashi et al. have performed a terahertz time-domain spectroscopy on TbMnO\textsubscript{3} in a wider energy range and found low-energy excitations, which cannot be assigned to phonons, at 2.5, 7.5, and 17 meV [4]. Although some theories tried to assign these excitation modes, their origins are still in debate. I will show our experimental data on low-energy magnetic excitations in TbMnO\textsubscript{3} investigated by chopper-type neutron spectrometers 4SEASONS and AMATERAS at J-PARC [5], and discuss the origins of electromagnons in TbMnO\textsubscript{3}.