## Longitudinal Collective Excitations in Intrinsic Josephson Junction Stacks with Two Tunneling Channels

**Y. Ota**[a, d], M. Machida[b, d], and T. Koyama[c, d]

[a]Advanced Science Institute, The Institute of Physical and Chemical Research (RIKEN), Wako, Japan
[b]CCSE, Japan Atomic Energy Agency, Tokyo, Japan
[c]Institute for Materials Research, Tohoku University, Sendai, Japan
[d]CREST (JST), Kawaguchi, Japan

Like high-$T_c$ cuprates, highly-anisotropic layered iron-based superconductors can exhibit Josephson effects even as the single crystal. In this paper, we construct a theory to describe transport phenomena along the $c$-axis in layered iron-based superconductors, motivated by recent experiments. One of the intriguing properties of the iron-based superconductors is that there are multiple superconducting gaps. This means that multiple tunneling paths for the Cooper pairs can open up. We propose that this systems are described as intrinsic Josephson junction stacks with multiple tunneling channels. We focus on a two-channel case. The theory predicts the presence of longitudinal Leggett collective excitations in addition to the conventional longitudinal Josephson plasma mode[1]. Inter-layer couplings and inter-band Josephson energy bring about a peculiar dispersion relation of the longitudinal Leggett mode. Specifically, this mode favors synchronous oscillations, in contrast to the Josephson plasma. This theoretical model and its results could contribute to the development of future applications.

[1]Y. Ota, M. Machida, and T. Koyama, Phys. Rev. Lett. **106**, 157001 (2011).