THEORY OF JOSEPHSON EFFECTS IN IRON-BASED MULTI-GAP SUPERCONDUCTOR JUNCTIONS

Y. Ota [1,3] **, M. Machida** [1,3,4] **, and T. Koyama** [2,3]

[1] *CCSE, Japan Atomic Energy Agency, 6-9-3 Higashi-Ueno, Taito-ku, Tokyo, 110-0015, Japan*

[2] *Institute for Materials Research, Tohoku University, 2-1-1 Katahira Aoba-ku, Sendai, 980-8577, Japan*

[3] *CREST(JST), 4-1-8 Honcho, Kawaguchi Saitama, 332-0012, Japan*

[4] *JST-TRIP, 5 Sambancho Chiyoda-ku, Tokyo, 102-0075, Japan*

E-mail: ohta.yukihiro@jaea.go.jp

Since the discovery of iron-based superconductors [1], Josephson junctions including such new materials have been intensively studied in order to explore their pairing symmetry and application potential. Recently, various types of iron-based superconductor junctions are successfully fabricated. One of interesting features of this type of materials is the presence of multiple (more than two) bands on Fermi surface and their contributions to superconductivity. As a result, iron-based superconductor junctions are possible to have multiple tunneling channels between the superconducting electrodes and relative charge fluctuations between the bands in each electrode. It is an urgent task to reveal how such multi-channel properties affect basic Josephson effects. In the present paper, we show a theory of Josephson junctions with multi-gap superconductors (i.e., multiple tunneling Josephson junctions). We mainly examine a heterotic (multi-band)superconductor- insulator-(single-band)superconductor junction [2]. Deriving an effective Lagrangian density based on the time-dependent Ginzburg-Landau model, we discuss how the relative fluctuations between multiple gaps (i.e., Leggett's collective excitation modes) and the pairing symmetry modify the Shapiro steps, e.g., the step height pattern and the step position.

References

[1] Y. Kamihara, T. Watanabe, M. Hirano, H. Hosono, *Iron-based layered superconductor* $La[O_{1-x}F_x]FeAs$ *(* $x = 0.05, 0.12$ *) with* $T_c = 26K$, J. Am. Chem. Soc. **130** 3296 (2008).

[2] Y. Ota, M. Machida, T. Koyama, and H. Mastumoto, *Theory of heterotic superconductor-insulator-superconductor Josephson junctions between single- and multiple-Gap superconductors*, Phys. Rev. Lett. **102**, 237003 (2009).