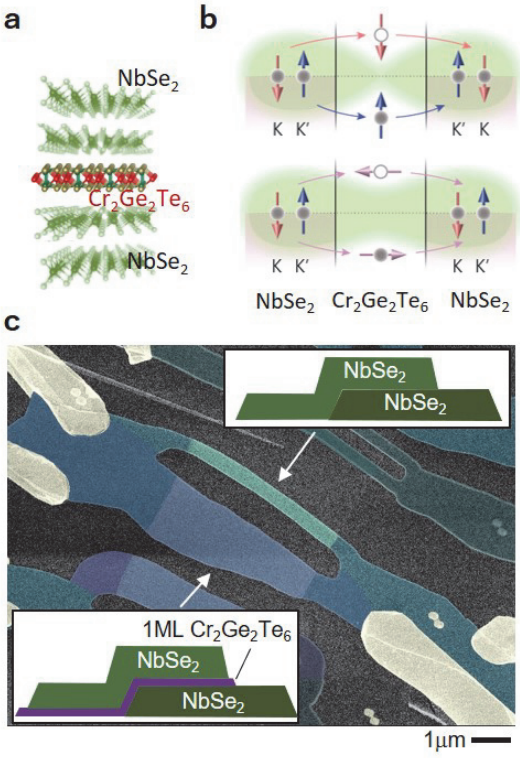
イジング超伝導体/2 次元磁性体ジョセフソン接合における異常ジョセフソン位相

東北大 AIMR[1]，ハーバード大物理[2] ○井土 宏[1]，キム フィリップ[2]

Tohoku Univ.[1], Harvard Univ.[2], ○Hiroshi Idzuchi[1], Philip Kim[2]

E-mail: idzuchi@tohoku.ac.jp

When two superconductors are connected across a ferromagnet, the spin configuration of the transferred Cooper pairs can be modulated due to magnetic exchange interaction. The resulting supercurrent can reverse its sign across the magnetic Josephson junction (JJ). The recent rise of 2D ferromagnets (F) and superconductors (S) provides an opportunity to build JJ with an atomically thin magnetic weak link formed in all crytallined junction. Here we demonstrate Josephson phase modulation in vertically stacked S-F-S van der Waals heterostructure, employing superconducting $NbSe_2$ and atomically thin magnetic insulator (MI) $Cr_2Ge_2Te_6$. We probe the phase of MI-JJ by constructing a SQUID based on MI JJs. We demonstrate a doubly degenerate non-trivial JJ phase, formed by momentum conserving tunneling of Ising Cooper pairs across magnetic domains in the $Cr_2Ge_2Te_6$ barrier. The doubly degenerate ground states in MI JJs provide a two-level quantum system that can be utilized as a new dissipationless component for superconducting quantum devices, including phase batteries, memories, and quantum Ratchets.



Acknowledgement & Reference.

This is studied in collaboration with F. Pientka, K.-F. Huang, K. Harada, Ö. Gül, Y. J. Shin, L. T. Nguyen, N. H. Jo, D. Shindo, R. J. Cava, and P. C. Canfield: H. Idzuchi *et al*. arXiv:2012.14969 (2020).

Figure caption.

a, schematic of $NbSe_2/Cr_2Ge_2Te_6/NbSe_2$ Josephson junctions (JJs). **b**, Illustration of the Ising-Cooper-pair coupling through the magnetic tunneling junction for perpendicular magnetization (top), for in-plane magnetization (bottom). For perpendicular magnetization, Ising Cooper pairs can tunnel via the spin-dependent energy levels without spin flip, forming a π phase junction. **c**, False-color SEM image of the SQUID device with and without a 1 ML $Cr_2Ge_2Te_6$ barrier.