2 次元磁性カゴメ格子におけるスピン蓄積と磁壁駆動に関する理論研究

Theoretical study of spin accumulation and domain wall motion in two-dimensional magnetic kagome lattice

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It is known that a two-dimensional electron system becomes a quantum Hall state and generates a chiral one-dimensional edge conduction when an external magnetic field is applied perpendicular the system. Similarly, this edge conduction is also induced in a magnetic material where the Chern number can be define in the presence of the magnetization, and it is called a “quantum anomalous Hall state”. If the magnetic material has an inhomogeneous magnetic texture, the chiral one-dimensional edge conductions are formed in each magnetic domain, and they have different directions from each other [1]. Because of the existence of localized charges on the domain wall, it is expected to control the domain wall by applying the external electric field.

We investigate the electrically induced spin accumulation around the magnetic domain wall in the two-dimensional quantum anomalous Hall ferromagnet theoretically. For details, we suppose a nanoribbon of a magnetic kagome lattice with Kane-Mele type spin-orbit coupling [2], [3] and exchange coupling to local magnetic moments, assuming each magnetic domain has the chiral one-dimensional edge conduction. And we calculate the spin density on each unit cell by the Kubo formula [4]. Consequently, the spin accumulation is observed around the edge of each domain and expected to influence the domain wall motion by acting as spin-orbit torque [5] in terms of the magnetization. Actually, by using the magnetization dynamics, it is shown that the domain wall starts to move as a result of the external electric field perpendicular to the domain wall.

These results mean that the domain wall in the quantum anomalous Hall ferromagnet can be controlled by the external electric field. And also, we suggest this model as a new mechanism for a spintronic device using the strong feature of the quantum anomalous Hall state which is the high-efficiency electron transport in its chiral edge state.

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