博士論文公聴会の公示 (物理学専攻)

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論文題目：Probing the Interfacial Dzyaloshinskii–Moriya Interaction in $SrRuO_3$-$SrIrO_3$ Bilayers via Magnetic Droplet Nucleation Models

（磁気液滴核形成モデルに基づく $SrRuO_3$–$SrIrO_3$ 二層膜における界面 Dzyaloshinskii–Moriya 相互作用の検出）

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場所： 理学研究科 H 棟 7 階セミナー室（H701 号室）

主査： 松野 丈夫

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論文要旨

Topologically protected spin structures have the potential to enable high-density, robust data storage devices and are therefore a focal point in modern spintronics and data-driven technologies. Transition metal oxides and their exotic phases are prominent candidates for this field, as many topologically non-trivial structures, such as skyrmions and incommensurate spin textures, can be realized under their strong spin-orbit coupling (SOC) paired with broken space-inversion symmetry. Identifying key materials and ways to maximize their potential for hosting spin structures is therefore critical for furthering this area of spintronics.

However, a commonly used tool for investigating such candidates, the topological Hall effect (THE), and its correspondence to actual topological structures is often contested. THE typically appears as a peak- or hump-like addition to the anomalous Hall effect (AHE) in transport measurements, stemming from chiral spin structures. Yet very similar signals can emerge from other mechanisms, such as overlapping AHE signals from different phases, challenging the reliability of THE as a probing tool.

A well-studied though still debated candidate system from the perovskite oxides is $SrRuO_3$ (SRO) interfaced with $SrIrO_3$ (SIO), typically grown on $SrTiO_3$ (STO). Ultrathin bilayers as well as SIO/SRO superlattices have been investigated intensively over the last decade with conflicting conclusions: while multiple papers reported THE signals or imaging of skyrmionic bubbles, others found false or manufactured THE-like signals and an absence of skyrmionic phases.

Yet in both cases, an important factor has not been measured directly in many of these kinds of systems: the coupling strength D of the Dzyaloshinskii-Moriya interaction (DMI).

This property, arising from SOC under broken space-inversion symmetry, is responsible for stabilizing skyrmions and related spin textures. In many cases, the presence of spin textures is therefore used to infer the DMI, whereas ideally D should be measured directly in order to predict the formation of these textures. This work aims to address this issue by investigating D first, before discussing the existence of skyrmions and associated THE signals in SIO/SRO bilayers.

In order to achieve this, a series of SIO(2)/SRO(t)/STO samples and a reference SRO/STO sample were prepared using pulsed-laser deposition (PLD) and investigated using both the magnetic full- and half-droplet nucleation models previously applied to other magnetic thin film systems. Through low-temperature transport measurements under tilted fields, the DMI was quantitatively extracted and compared to that of the uncapped single-layer system. The analysis indicates a clear and significant difference in the DMI between the bi- and single-layer system, suggesting a significant role of the interface-driven SOC in modifying chiral spin textures. While the approach provides qualitative insight into the interfacial DMI, the quantitative accuracy remains limited, emphasizing the need for complementary methods in future studies.