研究プロジェクト名: Topological spin textures in 2D van der Waals (vdW) magnet/heavy-metal structures

概要: Two-dimensional (2D) van der Waals (vdW) materials have recently gathered considerable attention owing to their prospect for low-power spintronic devices and quantum information science applications. The presence of strong spin-orbit coupling interactions leading to stabilization of long-range magnetic order down to the atomic limit, and flexibility with various elements and structures provides a fertile opportunity for the realization of emergent 2D magnetic texture-based novel spintronic devices. Clarification of the underlying physics governing the manifestation of exotic spin textures in 2D magnetic heterostructures and the possibility to tailor their properties through material and interface engineering is expected to enunciate deeper understanding of magnetism at low dimensions and pave the way for utilization of 2D magnets for conventional and unconventional computing devices.

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期待される研究成果：Previously, our experimental results have shown the existence of unconventional magnetic textures in single-crystalline bulk 2D magnet (Fig. 1(a)). We have also shown exceptional temperature insensitivity, and controllable size by breaking crystal inversion symmetry. Magneto-optical and electronic measurements in vdW magnet/heavy metal structures (Fig. 1(b)) and its comparison to single-crystalline bulk is expected to provide considerable insights into the underlying physics, show new directions towards utilization of emergent magnetic textures for spintronic devices. The obtained results are also prospective for the development of magnetic texture based spintronic devices for unconventional computing.

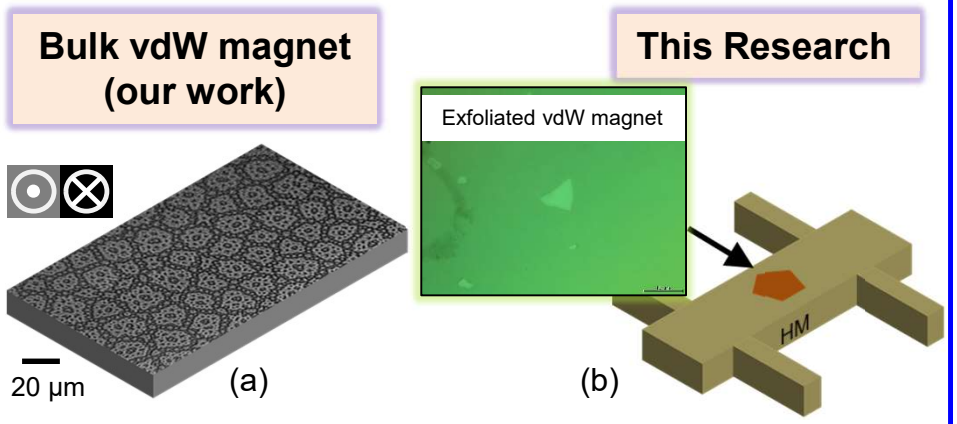

Figure 1: (a) Magneto-optic Kerr effect (MOKE) imaging of unconventional magnetic texture in a single-crystalline bulk vdW magnet Fe_3GeTe_2 (our work) (at T = 50 K). Grey (black) areas correspond to up (down) configurations of magnetic domains. (b) Schematic diagram of the proposed 2D vdW magnet/ heavy metal (HM) structure to be investigated in this study. Inset in (b) shows the optical microscope image of an isolated vdW ferromagnetic Fe_3GeTe_2 flake on substrate, achieved through mechanical exfoliation technique.

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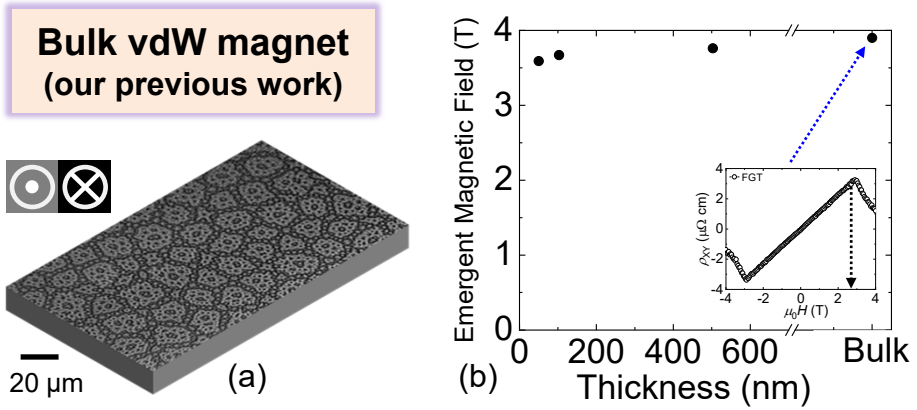
概要：　Two-dimensional (2D) van der Waals (vdW) materials have recently gathered significant attention owing to their prospect for low-power spintronic devices and quantum information science applications. The presence of strong spin-orbit coupling interactions leading to stabilization of long-range magnetic order down to the atomic limit, and flexibility with various elements and structures provides a fertile opportunity for the realization of emergent 2D magnetic texture-based novel spintronic devices. Clarification of the underlying physics governing the manifestation of exotic spin textures in 2D magnetic heterostructures and the possibility to tailor their properties through material and interface engineering is expected to enunciate deeper understanding of magnetism at low dimensions and pave the way for utilization of 2D magnets for conventional and unconventional computing devices.

研究成果（実施状況）：Using the vdW magnet Fe_3GeTe_2 (FGT, hereafter), we have demonstrated the existence of unconventional spin textures in a centrosymmetric structure (Fig. 1(a)) [1,2]. In this research, we have optimized and fabricated FGT and FGT/heavy metal structures using various device fabrication procedures. Interestingly, the underlying emergent magnetic field is virtually insensitive to FGT thickness (~ 50 nm) suggesting the possibility of an unconventional magnetic ground state even at reduced dimensions (Fig. 1(b)). Investigations concerning the effect of electrical current on the spin textures and emergent magnetic field under varying thickness are currently under investigation.



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主要発表論文等：[1] R. Roy Chowdhury, S. DuttaGupta *et al.*, Sci. Rep. 11, 14121 (2021).
[2] R. Roy Chowdhury, S. DuttaGupta *et al.*, Phys. Rev. Mater. 6, 014002 (2022).