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Lensless coherent imaging of nanoscale magnetic domains in 2D van-der-Waals materials

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Here, we present lensless coherent soft X-ray imaging of magnetic domains [1] in two-dimensional (2D) van der Waals (vdW) materials[2] at low temperatures and under strong magnetic fields. By integrating micron-scale flakes of 2D materials onto nano-fabricated holography masks—either through deterministic transfer in an inert-air glove box or via focused ion beam lamella preparation—we expand the applicability of soft X-ray holography to this emerging class of materials. This robus and versatile approach, illustrated in Figure 1, also enables the study of air-sensitive systems. We apply
it to probe complex magnetic domain structures and non-collinear spin configurations in various 2D vdW compounds at temperatures as low as 20 K and magnetic fields up to 2 T.

In addition to Fourier transform holography, we utilize holography-assisted phase retrieval [3] to enhance spatial resolution. Our results highlight the potential of lensless soft X-ray imaging—leveraging circular and linear dichroism, as well as element-specific contrast—to reveal nanoscale magnetic and electronic phenomena in 2D magnetic materials and related device architectures.

References:
[1] Eisebitt, S. et al. Nature, 432 (2004) 885–888
[2] Huang, B. et al. Nature 546 (2017) 270–273
[3] Battistelli, R. et al, Optica 11, (2024) 234-237

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Stemin2D-Sync –MINECO project MCIN/AEI PID2023-146354NB-C43,C41Figure 1: Methodology flow for lensless

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