Observing varied magnetic phases in a van der Waals antiferromagnet using widefield nitrogen-vacancy centre microscopy

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Interest in van der Waals materials often stems from a desire to miniaturise existing technologies by exploiting their intrinsic layered structure to create near atomically-thin components that do not suffer from surface defects. One appealing property is easily-switchable yet robust magnetic order, a quality only sparsely demonstrated in the case of in-plane anisotropy. In this work, we use widefield nitrogen-vacancy (NV) center magnetic imaging to measure the properties of individual flakes of $CuCrP_2S_6$, a multiferroic van der Waals magnet known to exhibit weak easy-plane anisotropy in the bulk. We chart the crossover between in-plane ferromagnetism in thin flakes down to the trilayer, and the bulk behaviour dominated by a low-field spin-flop transition. Further, by exploiting the directional dependence of NV center magnetometry, we are able to observe an instance of a predominantly out-of-plane ferromagetic phase near zero field, in contradiction with expectation and previous experiments on the bulk material. We attribute this to the presence of surface anisotropies arising from the sample preparation process or exposure to the ambient environment, which is expected to have more general implications for a broader class of weakly anisotropic van der Waals magnets.

[1] Alexander J. Healey, Sharidya Rahman, Sam C. Scholten, Islay O. Robertson, Gabriel J. Abrahams, Nikolai Dontschuk, Boqing Liu, Lloyd C. L. Hollenberg, Yuerui Lu, and Jean-Philippe Tetienne, *ACS Nano*, **Article ASAP**, DOI: 10.1021/acsnano.2c04132