Quantitative Magnetometry on Nanostructured MBE Grown 2D In-Plane Ferromagnet

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The discovery of ferromagnetic 2D van der Waals (vdW) crystals allows the study of novel magnetic phenomena at a reduced dimensionality [1,2]. Though different physical phenomena can be well studied in these crystals, they only offer limited control of their exact geometry. Contrary, in this study we investigate 2D $EuGe_2$ grown by molecular beam epitaxy (MBE) on a well-defined micron-sized structure.
$EuGe_2$ belongs to the lanthanide metalloxenes and exhibits an in-plane ferromagnetic intralayer coupling. While the interlayer coupling in bulk is antiferromagnetic, a net magnetic moment remains in the few layers limit [3]. We use the single spin of a nitrogen-vacancy in diamond embedded into an all-diamond atomic force microscope tip to directly measure the stray field of these structures quantitatively with a spatial resolution of around 50 nm. We are able to directly compare the magnetic properties of mono- and bilayer $EuGe_2$ and show that the net magnetic moment of the micron-sized structures evolves from a nano-sized magnetic substructure. Moreover, we determine how these properties are influenced by the geometry of the structure. By that, we provide the basis for targeted engineering of geometries to nucleate novel spin-textures and domain structures at a reduced dimensionality.

[1] B. Huang et al., Nature 546, 7657 (2017).
[2] C. Gong et al., Nature 546, 7657 (2017).
[3] A. Tokmachev et al., Mater. Horiz. 6, 7 (2019).