Controlling magnetic properties in layered 2D materials

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The growth of chalcogenide based thin films has come into focus due to the remarkable wealth of properties in this material family. While excellent crystalline periodicity arises from the strong and directional heteropolar bonds within individual layers which can originate long range order phenomena, such as magnetic order or the formation of permanent electric dipoles, the relatively weak interlayer interaction allows to combine different chemistries and different structures at the atomic scale. This opens a vast multi-dimensional materials design space in which nanoscale structure can be artificially designed to create desired material properties on demand. This puts thin film growth methods with inherent atomic level control, such as molecular beam epitaxy – the method of choice at the Paul-Drude-Institute – into the unique position to apply a bottom-up approach and to synthesize such artificial designer material systems.

In this talk I will highlight the magnetic and magnetotransport properties of the layered ferromagnetic metals Fe_3GeTe_2 and $Fe_{5-x}GeTe_2$, which can be grown by MBE directly on epitaxial graphene. Structural characterization shows very good crystalline quality. Magnetotransport along with magnetometric measurements have revealed that ferromagnetic order can be stabilized above room temperature by incorporating sufficiently high Fe amounts in this structure. It is further demonstrated that magnetocrystalline anisotropy, coercive field and Curie temperature can be engineered via the Fe content within the layers, making their heterostructure highly promising for tailor made exchange spring magnets and furthermore offer the possibility to artificially design skyrmionic systems.