2D Magnetic heterostructures: from artificial magnets to smart molecular/2D heterostructures

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The controlled assembly of 2D materials in van der Waals heterostructures provides the opportunity to design unconventional materials with novel properties. Here I will illustrate this concept through two examples:
1) Artificial magnets obtained by creating a twisted 2D heterostructure formed by two ferromagnetic monolayers of CrSBr twisted by an angle of 90º [1] Magneto-transport measurements in this new material show a multistep spin switching with the opening of hysteresis, which is absent in the pristine bilayer case (angle of 0º) [2], as a consequence of the competition between the inter-layer exchange interactions (which favor an antiparallel orientation of both spin layers), the local spin anisotropies (which tend to orient the spins along the easy axis of each monolayer, x and y) and an external magnetic field applied along one of these easy axes.
2) Smart molecular/2D heterostructures obtained by interfacing stimuli-responsive magnetic molecules with graphene, semiconducting layers (MoS_2 and WSe_2) or a superconducting layer ($NbSe_2$). The aim is that of tuning the properties of the "all surface" 2D material *via* an active control of the hybrid interface. As smart-molecular systems, I will choose magnetic spin-crossover materials able to switch between two spin states upon the application of an external stimulus (temperature, light or pressure) [3]. This spin transition is always accompanied by a significant change of volume in the material (by ca. 10%). Hence, it can generate strain over the 2D material leading to a reversible change in its physical properties triggered by temperature or light upon the spin transition [4-6].

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[6] M. Gavara-Edo *et al., Adv. Mater.* **34**, 2202551 (2022).