Towards neuromorphic materials on the atomic scale

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Artificial intelligence has made significant strides across various sectors, yet it relies on hardware, where data storage and processing are physically separated. Neuromorphic systems, however, aim at addressing this by integrating storage and processing in the same unit, and thus mirroring the brain's parallel and distributed computing without distinguishing between hardware and software. The vision of our effort is to develop neuromorphic atomic materials, that have both storage and processing capabilities and thus are capable of autonomously adapting and optimizing their performance, paving the way for new methods to create energy-efficient hardware for neural networks. We employ a bottom-up approach and use scanning tunneling microscopy (STM) to assemble spin structures atom-by-atom, allowing for precise control over material properties at the fundamental spatial limit. In these atomically designed spin systems, we harness properties such as frustration and stochasticity to achieve these dynamic, emergent behaviors. The project mainly relies on energy-landscape based machine learning models. In a combined effort between theoretical modelling and experimental implementation, we will focus on understanding how our atomic-scale model systems respond to more complex, realistic inputs and on exploring new computational links between quantum materials and deep learning.