Programmable magnetic polariton memory

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The discovery of excitons in magnetic van der Waals materials facilitates the study of exciton-polaritons in the presence of magnetic order [1]. Among these materials, the layered antiferromagnet CrSBr has emerged as a prototypical platform due to the large oscillator strength of its excitons. The strong interplay of excitons, photons, and ,magnetic order in CrSBr gives rise to a range of intriguing effects, including magneto-chromic responses [2], novel optical surface excitations [3], and fundamental exciton-magnon interactions [1, 3-4].

In this contribution, we show a technologically relevant but largely unexplored functionality of magnetic systems in the context of exciton-polariton physics: magnetic memory. Our experiments demonstrate that polaritons in a CrSBr microcavity can detect discrete magnetic domain textures, which can be initialized and modified by external magnetic fields, with sub-millielectronvolt precision. High-resolution measurements reveal striking (anti-) correlations between polariton energy and emission intensity, pointing to a deep connection of microscopic energy transfer processes, optical coupling, and magnetic domain textures. Notably, these magnetic domains exhibit long-term stability, making them ideal candidates for robust memory elements. Beyond that, our experiments show that key polaritonic properties—including excitation fluence dependence and nonlinear behavior—vary significantly with the underlying magnetic domain configuration. Two critical processes underlie the highly unconventional polariton behavior observed in our study: the hybridization of excitons and cavity photons and the reconfiguration of magnetic domains under optical excitation (cf. Fig. 1). To explore the latter, we systematically investigate the effects of pulsed and continuous-wave excitation as well as resonant and non-resonant driving schemes. Our findings demonstrate the potential of exciton-polaritons for all-optical control of magnetic memory, paving the way for novel applications in quantum and photonic information processing.

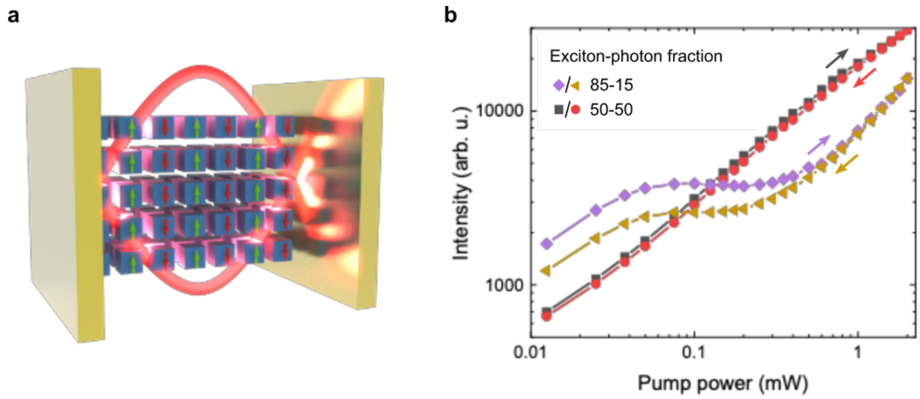

Figure 1: **a** Layered antiferromagnet CrSBr in a microcavity. In the presence of magnetic domains, polaritons behave differently. For example, **b** shows hysteretic luminescence emission obtained by sweeping the excitation power. Arrows indicate up and down sweeps.

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