Layer- and Field-Dependent Magnetic Order in 2D CrSBr Revealed by Pulsed Nanocalorimetry

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We report the first direct determination of the heat capacity (Cp) of few-layer CrSBr, a layered van der Waals antiferromagnet [1], using a microsecond-pulsed nanocalorimetry technique with sub-picojoule sensitivity [2]. The onset of magnetic order in CrSBr is reflected in Cp(T) through a distinct anomaly associated with the magnetic entropy change at the Néel transition, enabling direct thermodynamic access to magnetism in the 2D limit. The Cp(T) curves (Fig. 1a) reveal a pronounced anomaly around 132–140 K, whose amplitude and sharpness systematically evolve with layer thickness, from monolayer to bulk CrSBr, as well as a clear layer-parity effect arising from uncompensated ferromagnetic contributions in odd-layer samples. The technique also enables in-situ calorimetry under applied in-plane magnetic fields, showing that the antiferromagnetic transition is reversibly suppressed above a critical field (Fig 1b). Entropy analysis further shows that a substantial fraction of magnetic entropy is released over a broad temperature range above the Néel temperature, indicating the presence of short-range intralayer correlations prior to long-range order. These results establish microsecond-pulsed nanocalorimetry as a powerful platform to probe emergent magnetism and spin–lattice coupling in 2D materials, providing direct thermodynamic insight into the origin and dimensional evolution of magnetic order in van der Waals systems.

References

[1] Lee et al., Nano Lett. 21,3511–3517 (2021)
[2] H. Gómez-Torres et al., arXiv:2509.18019 (2025)

Figures

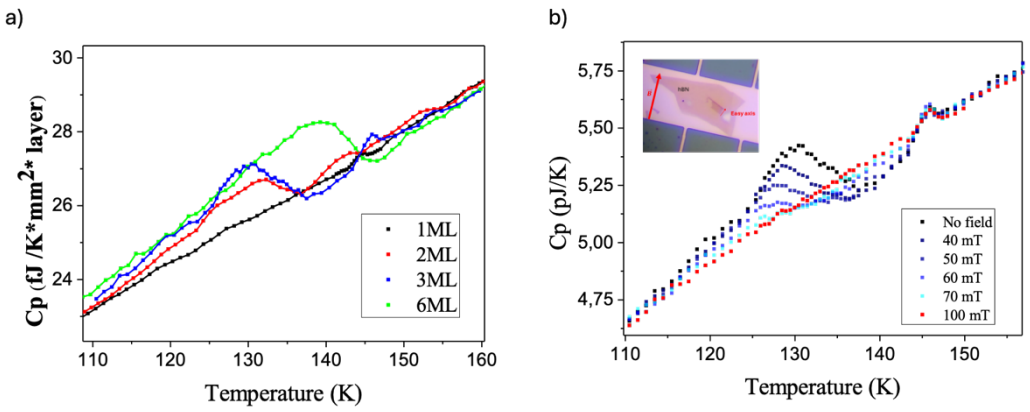

Figure 1: (a) Heat capacity *Cp (T)* of CrSBr flakes with different thicknesses. **(b)** Magnetic-field dependence of the *Cp (T)* in 3ML CrSBr.