Hump in Hall Measurements Insufficient Evidence for Skyrmions

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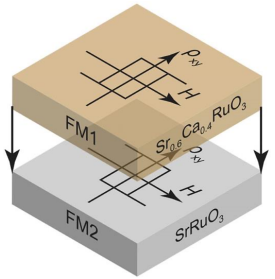
Molecular beam epitaxy is ideal for growing stacks of functional materials to utilize interfaces to create emergent phenomena such as magnetic skyrmions. Strontium ruthenate ($SrRuO_3$) and $SrRuO_3$-based heterostructures have been at the center of a debate on whether a hump-like feature appearing in Hall resistivities is sufficient evidence to prove the presence of skyrmions in a material.

Here, the **PARADIM In-House Team** synthesized a simple bilayer combining a positive anomalous Hall effect (AHE) layer ($Sr_{0.6}Ca_{0.4}RuO_3$) with a negative AHE layer ($SrRuO_3$). The bilayer shows a hump-like feature in the Hall resistivity that closely resembles the one often attributed to skyrmions. Multiple tests for skyrmions were performed, but no evidence of their existence was found.

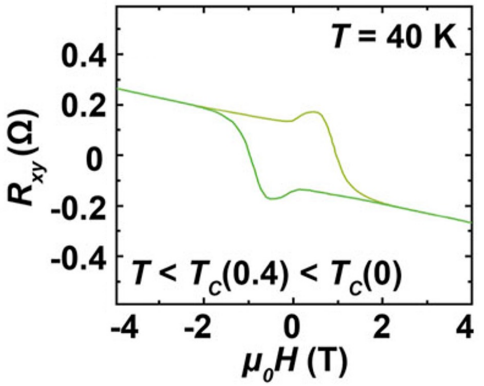
In related work, the **team demonstrated the highest residual resistance ratio**, RRR = ρ [300 K]/ρ [4 K] = 205, for $SrRuO_3$ thin films ever achieved. RRR is a measure of film quality, and our results exceed the best films grown by others using machine learning (RRR = 80) as well as the best single crystals (RRR = 162). This achievement shows the power of a team-based approach to synthesis science.

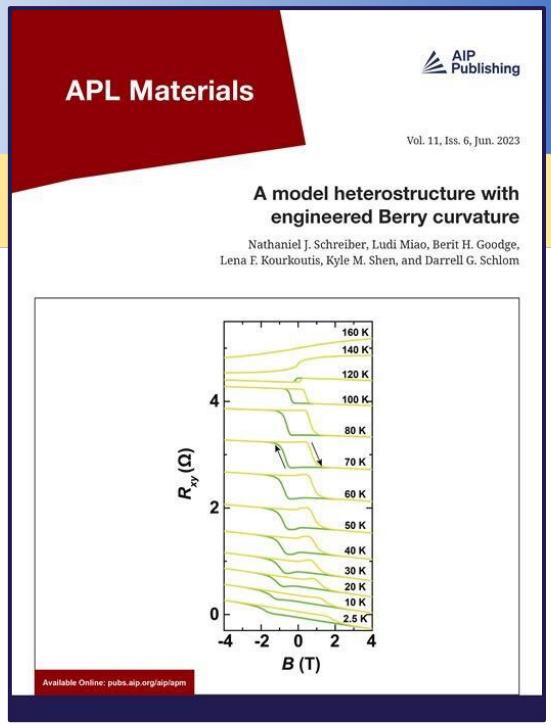
N.J. Schreiber, *et al.* Journal cover *APL Mater.* June 2023, *APL Mater.* **11**, 111101 (2023), *APL Mater.* **11**, 061117 (2023).
Data DOI: 10.34863/36tx-c606.

Structure

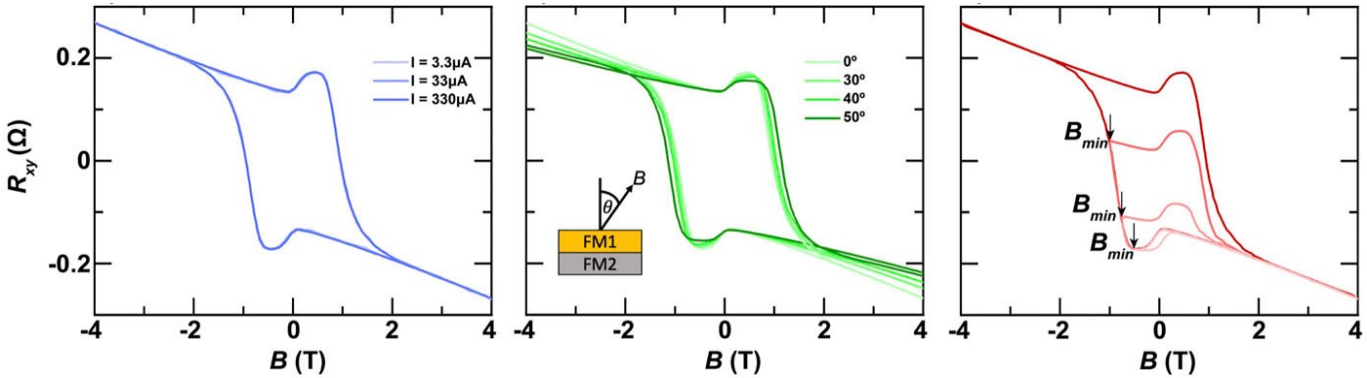


Anomalous Hall Effect





Tests for Skyrmions



Skyrmions should be affected by: (1) the current density, but is not seen in transverse resistance, R_{xy}, at various currents, where all measurements almost perfectly overlap (left); (2) the canting angle, expecting a significant drop off in R_{xy}, but is not seen for angles up to 50° (center); and (3) minor loops of R_{xy}, measured with various B_{min}, but hysteretic behavior like this is not consistent with the presence of skyrmions (right).