Supplementary Material

Two-dimensional J_{eff} = 1/2 antiferromagnetic insulator unraveled from interlayer exchange coupling in artificial perovskite iridate superlattices

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In this Supplementary Material, we provide detailed structural characterizations and magnetic measurements, demonstrating that the sample qualities are consistent, comparable and repeatable.

(1) Strain analysis

In order to investigate the epitaxial strain in the SLs, we did reciprocal spacing mapping (RSM) of each sample. As shown below, all the SLs have the same in-plane lattice parameters since they share it with that of the substrate. This proofs that all the films were coherently grown. In other words, all the $SrIrO_3$ layers in the SLs host the same epitaxial strain. Based on comparisons with Sr_2IrO_4, we estimate that a sizeable epitaxial strain (several %) or an unrealistic large variation of oxygen defect concentration (about 50%) would be required to cause the large changes in Neel temperatures as we observed [40, 41]. Therefore, according to the RSM data here, the variation of ordering temperatures represents intrinsic changes of ordering parameters with *m*.

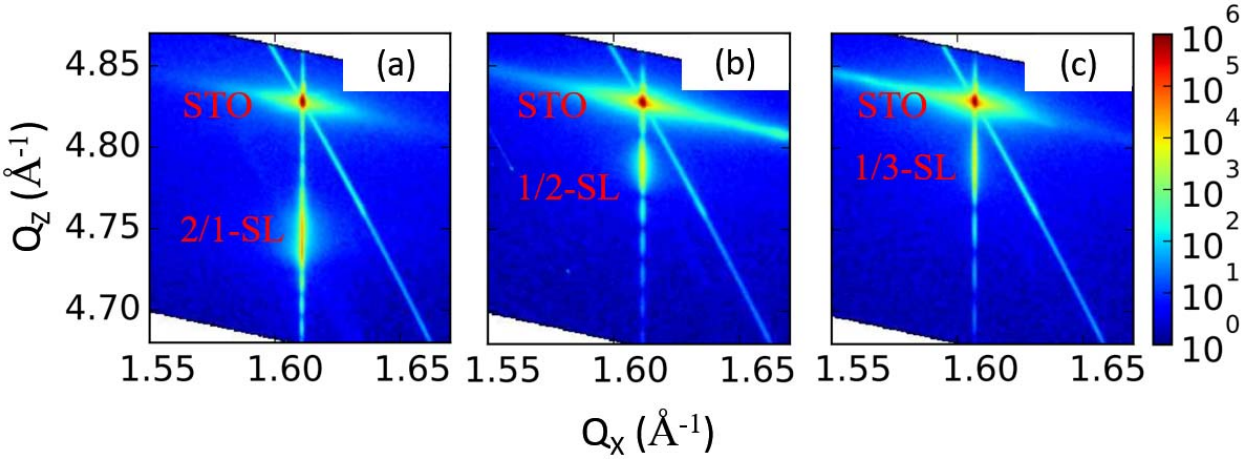

Figure S1. Reciprocal spacing mapping of the 2/1-SL (a), 1/2-SL (b) and 1/3-SL (c) around the (103) (pseudo-cubic) film peak.

References

[40] O.B. Korneta, T. Qi, S. Chikara, S. Parkin, L.E. De Long, P. Schlottmann, G. Cao, Phys. Rev. B **82**, 115117 (2010).

[41] A. Lupascu, J.P. Clancy, H. Gretarsson, Z. Nie, J. Nichols, J. Terzic, G. Cao, S.S.A. Seo, Z. Islam, M.H. Upton, J. Kim, D. Casa, T. Gog, A.H. Said, V.M. Katukuri, H. Stoll, L. Hozoi, J. van den Brink, Y.-J. Kim, Phys. Rev. Lett. **112**, 147201 (2014).

(2) Film interface structure

We did x-ray reflectivity and rocking curve measurements, to investigate interface roughness and mosaicity, respectively. The thickness fringes on all film's reflectivity curves (Fig. S2) indicates sharp interface between each layer. The deduced roughness by fitting the reflectivity data is

lower than 2 □ for all the samples. Figure S3 illustrates the rocking curves of all the SLs as well as one typical STO substrate. One can see that the SLs have comparable width which is equally narrow as that of the single crystal substrate. The result indicates that the mosaicity of the SLs are very close and set by the substrate.

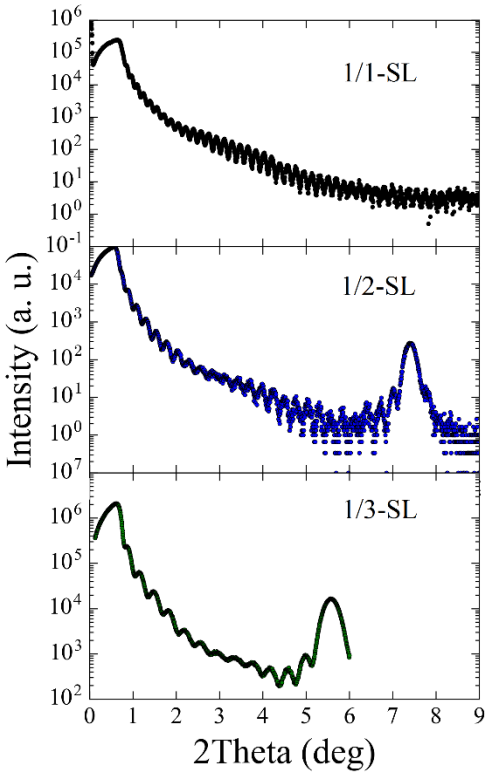

Figure S2. X-ray reflectivity data of three SLs.

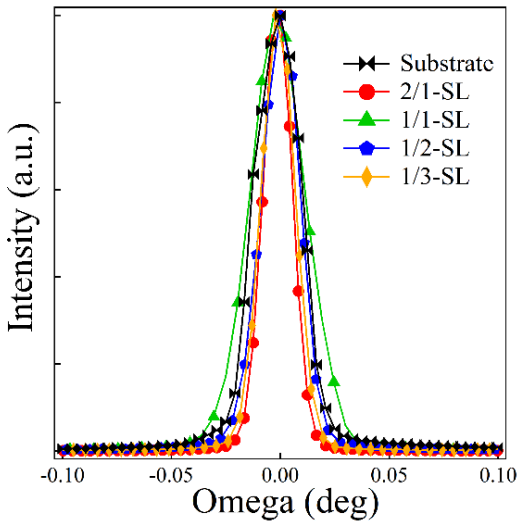

Figure S3. Rocking curves around the (002) pseudo-cubic peak.

(3) To demonstrate the reproducibility, Figure S4 shows the remnant magnetization versus temperature of two samples for each member of the SL series. The transition temperatures as well as the magnetizations are repeatable within our experimental error.

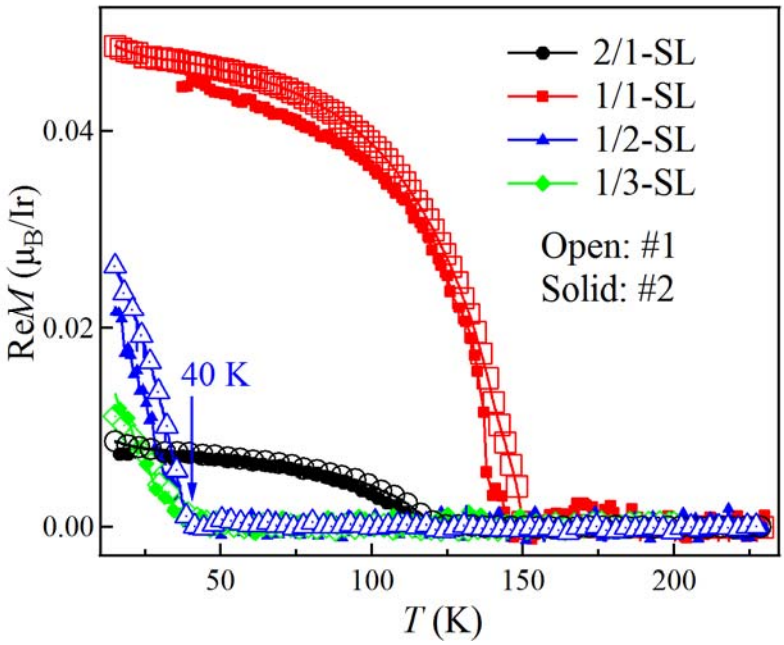

Figure S4. Remnant magnetization versus temperature of two different samples for each SL combination.