Supplementary Information

Observation of Griffith's phase-like magnetic behavior in a frustrated antiferromagnetic system: Sr_2InRuO_6

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Figure S1: ***Fig.* S1 (a)** shows the X-ray diffraction (*XRD*) patterns of sample 1 (synthesized at 1250 °C) and sample 2 (synthesized at 1050-1150 °C, see manuscript). *XRD* patterns of both samples match well with the standard *XRD* pattern of Sr_2YRuO_6 and suggest the synthesis of the desired materials. Further, the impurity peak (shown by the star mark in ***Fig.* S1** inset) has diminished in the sample synthesized at lower temperatures. This further suggests that the minute (3% - 5%) nonmagnetic impurity peak of h-In_2O_3 is resulting from the Ru sublimation at higher temperatures. ***Fig.* S1 (b)** and **(c)** show the simulated *XRD* patterns, using the standard *XRD* data of Sr_2YRuO_6 (ICSD collection code 192766) along with the experimental *XRD* patterns of sample 1 and sample 2. FullProf software was used for the structural refinements. The obtained structural information, like space group, lattice parameters and atomic positions are tabulated in *Table* S1 and *Table* S2.

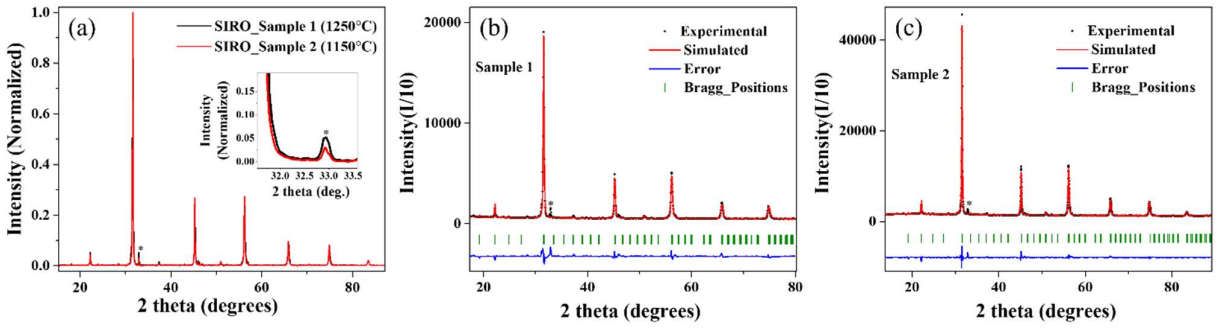

Fig. S1: (a) *XRD* patterns of sample 1 and sample 2 are shown. The inset shows an enlarge view of the nonmagnetic h-In_2O_3 impurity peak. The *XRD* patterns were aligned at the highest intensity peak position for a better comparison. (b) and (c) show the simulated diffraction patterns along with the experimental *XRD* patterns of sample 1 and sample 2, respectively.

Table S1: *Table* S1 provides the structural information, like lattice parameters, space group and goodness of fit obtained from the refinement of the *XRD* patterns of sample 1 and sample 2.

Sample	a (Å)	b (Å)	c (Å)	β (deg)	Space group	R_p	R_{wp}	χ^2
Sample 1 (1250°C)	5.6654 (±0.0011)	5.6746 (±0.0009)	8.0172 (±0.0024)	90.0813 (±0.1626)	P 2_1/n	4.33	7.61	4.23
Sample 2 (1150°C)	5.6729 (±0.0010)	5.6774 (±0.0009)	8.0129 (±0.0012)	90.0478 (±0.0192)	P 2_1/n	2.36	4.02	2.78
						Conventional		
						14.6	11.7	2.783

Table S2: *Table* S2 provides the atomic positions obtained from the refinement of the XRD patterns of the synthesized samples.

Atomic Coordinates			
Atom	x	y	z
Sr	0.00282	0.00778	0.24385
In	0.50000	0.00000	0.00000
Ru	0.50000	0.00000	0.50000
O1	0.35310	0.30045	-0.03100
O2	0.23153	0.78701	0.00011
O3	0.01450	0.47661	0.24959

Figure S2: A characteristic of the formation of Griffith's phase (*GP*) in certain systems is the power law variation of inverse susceptibility, χ^{-1}, given by an equation of the form $\chi^{-1} = \left(T - T_c^{rand}\right)^{1-\lambda_G}$, where $0 \leq \lambda_G < 1$ [1,2,3]. To estimate the value of the exponent λ_G, both Curie-Weiss temperature (θ_{cw}) and transition temperature (T_N *or* T_C) have previously been used for T_c^{rand}. However, for antiferromagnetic systems[1], a better choice for T_c^{rand} is a value close to θ_{cw}, which makes λ_G approximately zero in the paramagnetic phase. We have used a T_c^{rand} value of ≈ - 257 K, which is very close to the θ_{cw}(≈ - 265 K) of Sr_2InRuO_6 obtained from the Curie-Weiss fitting of the inverse susceptibility data shown in ***Fig.* 3(d)** of the main manuscript, to ensure λ_G to be nearly zero in the paramagnetic phase. A linear fit (***Fig.* S2**) of the low

temperature region thus obtained the value of λ_G to be ~ 0.624. This estimated exponent is in close agreement with the values obtained for several *GP*-containing compounds[1,2,3].

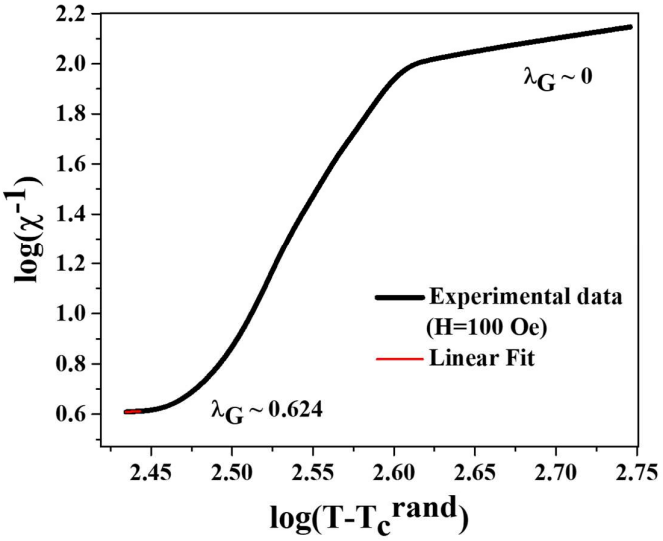

Fig. S2: A log-log plot χ^{-1} vs $(T - T_c^{rand})$ is shown. Red line shows the linear fit. The extracted value of λ_G from the linear fit is provided.

Figure S3:

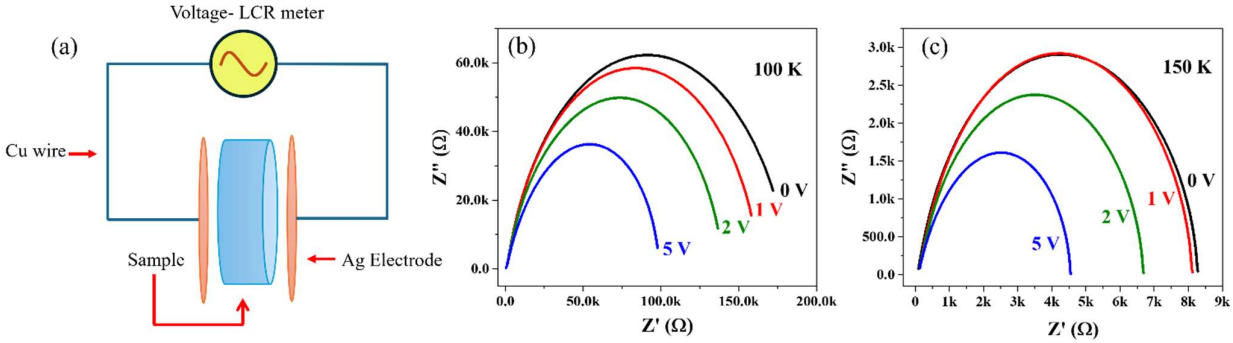

Fig. S3: (a) A schematic representation of the dielectric measurement setup. The Nyquist (Cole-Cole) plots (b) and (c), obtained from the measured complex impedance (Z*) of the SIRO sample at 100 K and 150 K, respectively, are asymmetric. This suggests the presence of more than one R-C element in the circuit. The effects of dc-bias are clearly visible in these plots.

References:

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2) W. Jiang, X. Z. Zhou, G. Williams, Y. Mukovskii, and K. Glazyrin, Griffiths phase and critical behavior in singlecrystal $La_{0.7}Ba_{0.3}MnO_3$: Phase diagram for $La_{1-x}Ba_xMnO_3$ (x ≤0.33), *Phys. Rev. B*, 2008, **77**, 064424.

3) S. Guo, D. P. Young, R. T. MacAluso, D. A. Browne, N. L. Henderson, J. Y. Chan, L. L. Henry, and J. F. Ditusa, Discovery of the Griffiths phase in the itinerant magnetic semiconductor $Fe_{1-x}Co_xS_2$, *Phys. Rev. Lett.*, 2008, **100**, 017209.