

Quantum liquid from strange frustration in the trimer magnet Ba₄Ir₃O₁₀

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Supplementary Methods

Single crystals of Ba₄Ir₃O₁₀ (and Sr doped Ba₄Ir₃O₁₀) were grown using a flux method from off-stoichiometric quantities of IrO₂, BaCO₃ (and SrCO₃) and BaCl₂ in a weight ratio of 1:10:2.7. The mixture was fired at 1460 C for 10 hours and then slowly cooled to room temperature at a rate of 4 C/hour. Platinum crucibles were used. The average sample size is approximately 3 x 2 x 1 mm³. Measurements of crystal structures were performed using a Bruker Quest ECO single-crystal diffractometer equipped with a PHOTON 50 CMOS detector. It is also equipped with an Oxford Cryosystem that creates sample temperature environments ranging from 80 K to 400 K during x-ray diffraction measurements. Chemical analyses of the samples were performed using a combination of a Hitachi MT3030 Plus Scanning Electron Microscope and an Oxford Energy Dispersive X-Ray Spectroscopy (EDX). Magnetic properties were measured using a Quantum Design (QD) MPMS-7 SQUID Magnetometer with a rotator that enables angular measurements of magnetic properties. Standard four-lead measurements of the electrical resistivity were carried out using a QD Dynacool PPMS System equipped with a 14-Tesla magnet. The heat capacity was measured down to 0.05 K using a dilution refrigerator for the PPMS.

Thermal conductivity measurements were performed with a one-heater, two-thermometer configuration, with the temperature gradient along the *c* axis. Cernox resistors were used as

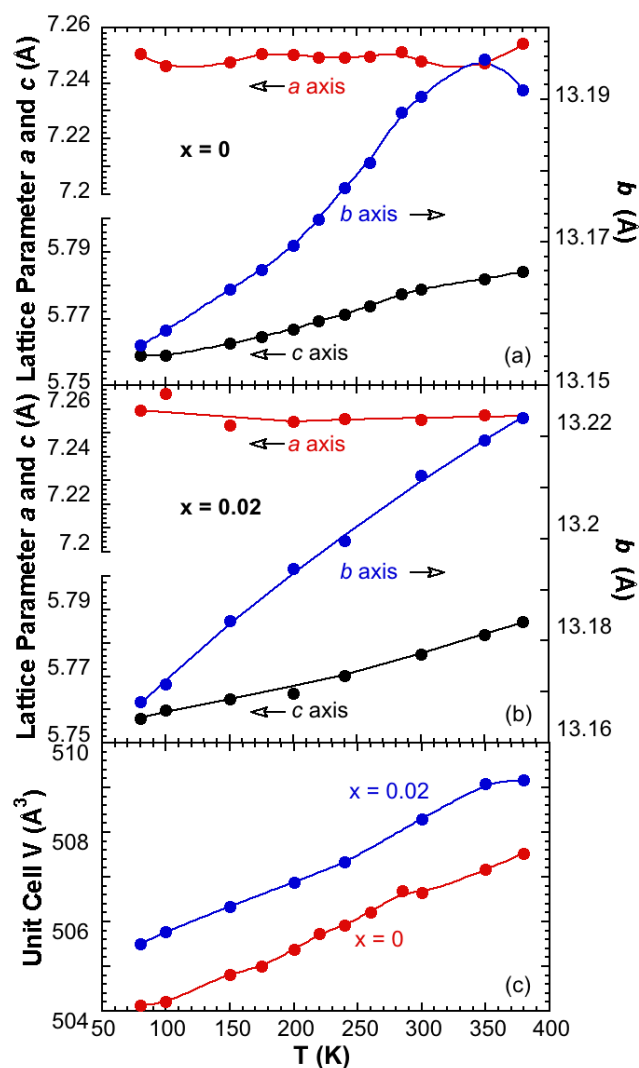
thermometers for the reported temperature range ($T > 1.8$ K) and calibrated separately in situ under the applied field. The sample was mounted in a mini-vacuum cell, which was specially designed to be mounted in the rotation probe, that enables the external magnetic field to be aligned parallel with the c-axis [i.e. along the temperature gradient] and perpendicular to the out-of-plane direction. Temperature gradient $|\Delta T|$ is maintained below 3% of the bath temperature to avoid heating.

The crystal structure of $\text{Ba}_4\text{Ir}_3\text{O}_{10}$ was also studied using single crystal neutron diffraction using the time-of-flight Laue diffractometer TOPAZ. The data were collected on crystal with a volume of approximately 1.0 mm^3 for 70 minutes at every orientation. A total of approximately 20 hours was spent to collect the data at 100 K. Sample orientations were optimized for an estimated 99% coverage of symmetry-independent reflections of the monoclinic cell. The raw Bragg intensities were obtained using a 3D ellipsoidal integration method. Data reduction including Lorentz, absorption, TOF spectrum, and detector efficiency corrections were carried out. The reduced data were exported to the GSAS program suite for wavelength dependent extinction correction and refined to convergence using SHELXL-97.

Supplementary Crystal Structure

$\text{Ba}_4\text{Ir}_3\text{O}_{10}$ adopts a monoclinic structure with a $P2(1)/c$ space group. The room-temperature lattice parameters are $a = 7.246 \text{ \AA}$, $b = 13.1615 \text{ \AA}$ and $c = 5.759 \text{ \AA}$ and $\beta = 113.27^\circ$. The temperature dependence of the lattice parameters is shown in **Supplementary Fig.1a**. The Ir1-Ir2 distance within each trimer is equally $2.5760 \text{ \AA}$ at 100 K, implying the same valence state for Ir1 and Ir2 ions in the trimers. The two outside IrO_6 octahedra in each trimer are slightly distorted due chiefly to the connection to the neighboring trimers whereas the middle IrO_6 octahedron is undistorted.

$\text{Ba}_4\text{Ir}_3\text{O}_{10}$ was reported to have Cmca space group in an early study [1]. However, there are Bragg peaks violating the reflection condition of the Cmca space group. For example, the $(h, 0, l)$ peaks with $l=2n+1$ are observed, which should be absent for the Cmca space group. In addition, refinement forcing the structure in the Cmca yields abnormal thermal displacement of the oxygen sites. Thus, the crystal structure has to be reduced to a lower $\text{P2}_1/\text{c}$ space group, which is consistent with another early work [2].



Supplementary Fig. 1. Temperature dependence of lattice parameters, a , b , and c axis for (a) $x = 0$ and (b) $x = 0.02$. Note that Sr doping changes the lattice parameters but causes no structural

changes. (c) Unit cell V for comparison between $x = 0$ and $x = 0.02$. Note that V is expanded for $x = 0.02$ despite the fact that the ionic radius of Sr is smaller than that of Ba.

The 2% Sr substitution for Ba causes no structural changes but expands the unit cell V by up to 0.3 %, as shown in **Supplementary Fig. 1b and 1c**. The unit cell expansion is surprising not only because the expansion is caused by such a low doping level but also because the ionic radius of the Sr ion (1.18 Å) is considerably smaller than that of the Ba ion (1.35 Å). In particular, the lattice parameter a axis is shortened slightly but both the b and c axis are significantly elongated (see **Supplementary Fig. 1b**).

Structural details can be found in **Supplementary Table I**.

Supplementary Table I. Structural parameters for single-crystal $Ba_4Ir_3O_{10}$ ($x=0$) and $(Ba_{0.98}Sr_{0.02})_4Ir_3O_{10}$ ($x=0.02$) with $P2_1/c$ (No. 14) phase at 100 K, data obtained from single-crystal neutron diffraction.

x = 0 T = 100 K		$a = 7.2545(6)$ Å, $b = 13.192(1)$ Å, $c = 5.7737(5)$ Å, $\beta = 113.513(8)^\circ$, $V = 506.66(8)$ Å ³ . The agreement factor $R_1 = 4.83\%$ was achieved by using 1322 unique reflections with $I > 2\sigma$ and resolution of $d_{min} = 0.65$ Å. Anisotropic atomic displacement parameters were used for all elements.				
	Site	x	y	z	Occupancy	Ueq(Å ²)
Ba1	4e	0.0731(2)	0.6389(1)	0.0327(6)	1	0.0034(3)
Ba2	4e	0.5205(2)	0.3870(2)	0.2643(5)	1	0.0064(2)
Ir1	2a	0	0	0	1	0.0052(2)
Ir2	4e	0.2503(1)	0.1496(1)	0.1322(2)	1	0.0049(2)
O1	4e	0.0680(2)	0.6503(1)	0.5261(2)	1	0.0054(3)
O2	4e	0.2204(4)	0.0314(1)	0.3381(3)	1	0.0057(3)
O3	4e	0.2192(4)	0.4620(1)	0.3757(3)	1	0.0061(4)
O4	4e	0.5420(2)	0.1518(1)	0.2741(6)	1	0.0104(3)
O5	4e	0.2423(3)	0.2391(2)	0.4023(3)	1	0.0157(4)

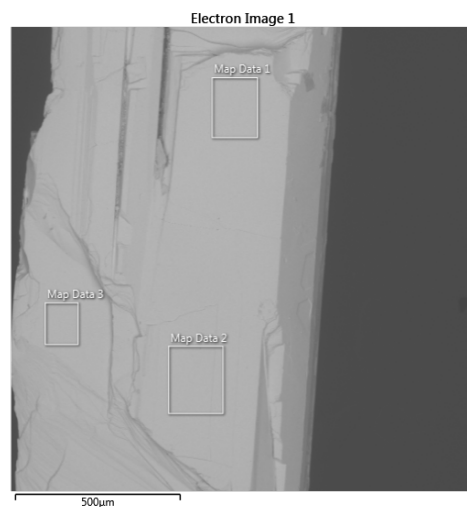
x = 0.02 T = 100 K		$a = 7.281(1)$, $b = 13.196(2)$ Å, $c = 5.771(1)$ Å, $\beta = 113.75(1)^\circ$, $V = 507.57(9)$ Å ³ . The agreement factor $R_1 = 6.55\%$ was achieved by using 1393 unique reflections with $I > 2\sigma$ and resolution of $d_{min} = 0.65$ Å. Anisotropic atomic displacement parameters were used for all elements.				
	Site	x	y	z	Occupancy	Ueq(Å ²)
Ba1	4e	0.0752(4)	0.6388(2)	0.0299 (6)	0.93(2)	0.0078(7)
Ba2	4e	0.5207(4)	0.3873(2)	0.2655(6)	0.97(2)	0.0096(7)
Ir1	2a	0	0	0	1	0.0081(3)
Ir2	4e	0.2497(2)	0.1496(1)	0.1360(3)	1	0.0073(3)
O1	4e	0.0678(4)	0.6503(2)	0.5193(6)	1	0.0092(4)
O2	4e	0.2241(4)	0.0282(2)	0.3408(5)	1	0.0094(5)

O3	4e	0.2155(5)	0.4598(2)	0.3718(5)	1	0.0088(5)
O4	4e	0.5415(4)	0.1522(2)	0.2745(7)	1	0.0153(4)
O5	4e	0.2428(5)	0.2330(2)	0.4202(5)	1	0.0136(5)

Supplementary EDX and SEM Results

1. Pure $\text{Ba}_4\text{Ir}_3\text{O}_{10}$

Here is the SEM image and the numerical EDX results of single-crystal $\text{Ba}_4\text{Ir}_3\text{O}_{10}$.



Supplementary Fig.2. The SEM image of single-crystal $\text{Ba}_4\text{Ir}_3\text{O}_{10}$ studied

Supplementary Table II The EDX data for $\text{Ba}_4\text{Ir}_3\text{O}_{10}$

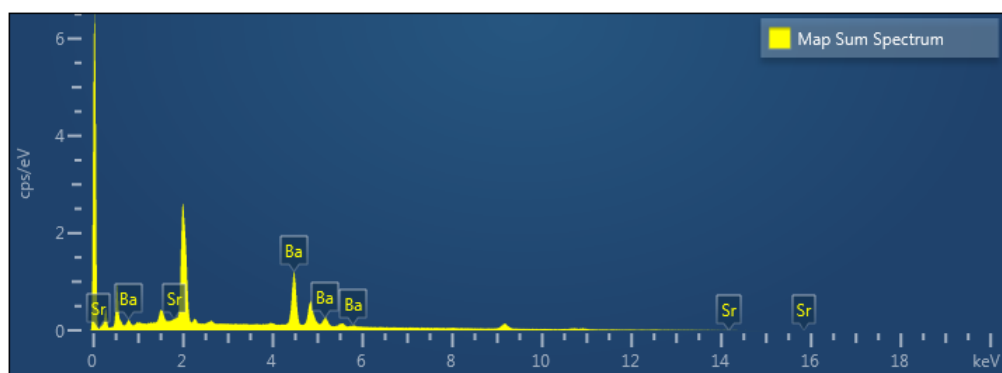
Map Sum Spectrum				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
Ba	L series	48.94	0.20	57.28
Ir	M series	51.06	0.20	42.72
Total		100.00		100.00

2. 2% Sr-doped $\text{Ba}_4\text{Ir}_3\text{O}_{10}$

The Sr-concentration is 2.1% determined by the EDX data shown below



Supplementary Fig.3. The SEM image of 2% Sr-doped $Ba_4Ir_3O_{10}$



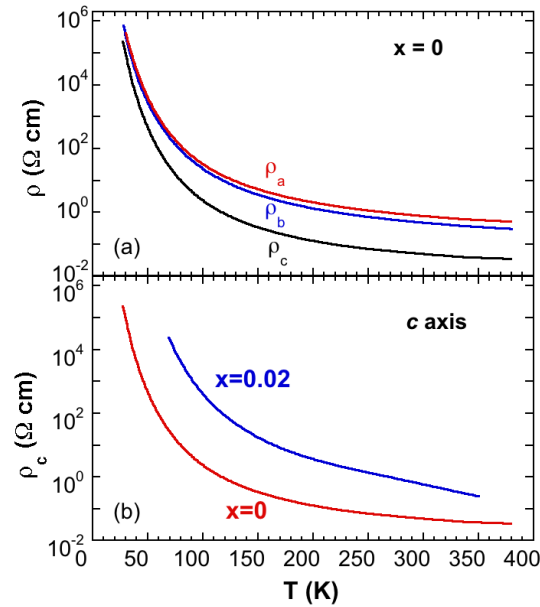
Supplementary Fig.4. The EDX spectrum of 2% Sr-doped $Ba_4Ir_3O_{10}$

Supplementary Table III The EDX data for 2% Sr-doped $Ba_4Ir_3O_{10}$

Map Sum Spectrum Element	Line Type	Weight %	Weight % Sigma	Atomic %
Ba	L series	47.57	0.30	55.59
Ir	M series	51.79	0.30	43.24
Sr	L series	0.64	0.14	1.17
Total		100.00		100.00

Supplementary Electrical Resistivity

$\text{Ba}_4\text{Ir}_3\text{O}_{10}$ ($x = 0$) exhibits an insulating behavior as shown in **Supplementary Fig. 5a**. A fit of ρ to an activation law for a temperature range of 130 - 400 K gives rise to an activation gap of 0.1 eV. Below 30 K, ρ rises more rapidly and becomes too large for measurements. Interestingly, 2% Sr substitution for B increases ρ significantly; for example, the resistivity along the c-axis ρ_c is increased by up to two orders of magnitude (**Supplementary Fig.5b**).

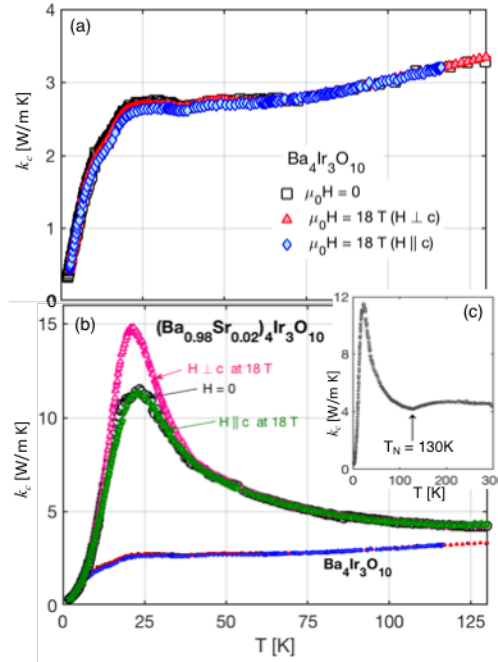


Supplementary Fig. 5. Temperature dependence of electrical resistivity ρ for (a) $x = 0$ and (b) ρ_c for $x = 0$ and $x = 0.02$ for comparison. Note that $x = 0.02$ becomes more insulating.

Supplementary Thermal Conductivity of $x =$ and $x = 0.02$

The electronic contribution in $x = 0$ is estimated least three orders of magnitude smaller than expected based on the Wiedemann-Franz law, and thus unessential for $x = 0$. Importantly, the behavior of k_c remains unchanged at 18 T (**Supplementary Fig.6a**). As seen in the main text, k_c is

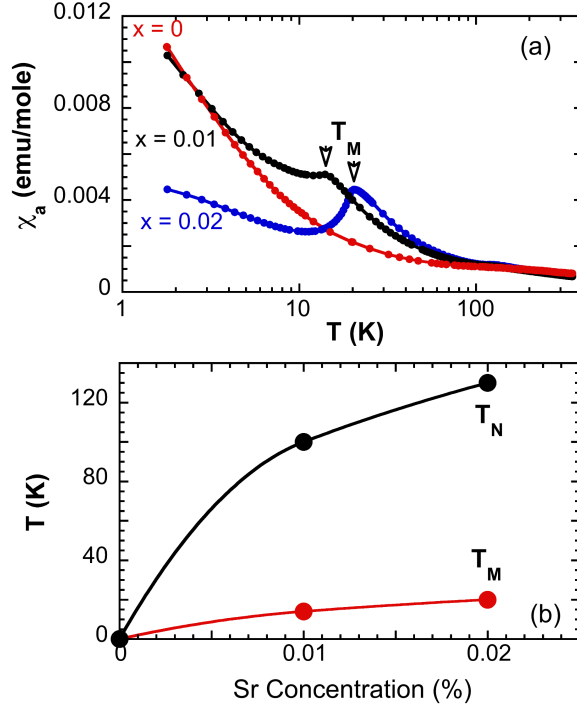
vastly different between $x = 0$ and 0.02 not only for the magnitude at low temperature ($T < 100$ K) but also its temperature dependence. For $x = 0$, $\kappa_c(T)$ is strikingly unusual compared to that of $x = 0.02$ and of other insulators. Specifically, k_c for $x=0$ decreases slowly and monotonically before plummeting below 25 K; in sharp contrast, k_c for $x = 0.02$ is considerably enhanced and peaks near 20 K (**Supplementary Fig6b**). The magnetic ordering in $x = 0.02$ is marked by a kink in k_c at $T_N \approx 130$ K (**Fig. 3c**), indicating significant spin-phonon scattering present. The absence of the peak in k_c for $x = 0$ implies the existence of *strong spin fluctuation* that prevents such a phonon peak from emerging. This is consistent with the extremely large frustration parameter $f(=3800)$ and also explains the exceptionally low value of k_c . The energy scale of spin fluctuation is apparently larger than 18 T, thus the lack of the field dependence in $x = 0$ but it must be much smaller in $x=0.02$ as k_c is enhanced by up to 20% at the same magnetic field (**Supplementary Fig.6b**). It is worth to be pointed out that 2% Sr causes concurrent significant increases in electrical resistivity and the thermal conductivity, suggesting an inconsequential role of electrons in k_c . Furthermore, k_c for $x = 0.02$ increases for $H \perp c$ in the vicinity of peak, but remains essentially unchanged for $H \parallel c$, the temperature gradient direction. The origin of the enhancement is still unclear; it is speculated that the direction of $H \perp c$ may be more aligned with the magnetic easy axis, the a axis (see Fig.4a in the main text and below), and the applied field along the easy axis may suppress thermally-excited incoherent magnons, thus enhancing the mean free of path of phonons.



Supplementary Fig. 6. (a) k_c for $x = 0$ at $H = 0$ and $\mu_0 H = 18 \text{ T}$ with $H \parallel c$ and $H \perp c$. k_c remains essentially unchanged at 18 T. (b) k_c for $x = 0.02$. k_c changes with H when $H \perp c$. (c) T_N in $x = 0.02$ (arrow) is marked by a kink in $k_c(T)$.

Supplementary Data for Evolution of Magnetization with Slight Sr Doping

The magnetic behavior sensitively changes with x , as clearly illustrated in **Supplementary Fig.7**.

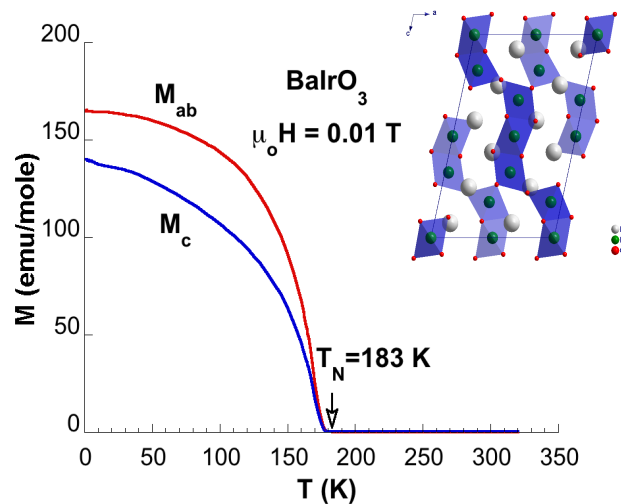


Supplementary Fig. 7. (a) The a -axis magnetic susceptibility, χ_a , for $x = 0, 0.01$ and 0.02 at 1.8 K and up to 14 T. (b) T_N and T_M as a function of x .

Supplementary Comparison with Sister Compound BaIrO_3

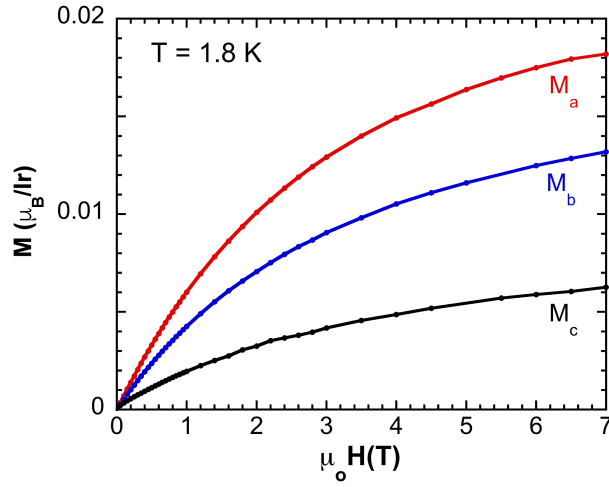
BaIrO_3 antiferromagnetically order at $T_N = 183$ K, as shown in **Supplementary Fig. 8**, in sharp contrast to $\text{Ba}_4\text{Ir}_3\text{O}_{10}$. Like $\text{Ba}_4\text{Ir}_3\text{O}_{10}$, BaIrO_3 also features three face-sharing IrO_6 octahedra forming Ir_3O_{12} trimers that are vertex-linked to construct one-dimensional chains along the c -axis. Usually face-sharing IrO_6 octahedra are believed to produce stronger exchange via the shorter Ir-Ir distance in the face sharing geometry. Under this assumption, the Ir3 trimers present in $\text{Ba}_4\text{Ir}_3\text{O}_{10}$, as well as in its sister compound BaIrO_3 , would form the strongest magnetic bonds, which for AFM interactions would produce a single Kramer's doublet effective-spin-half out of each trimer. The lattice formed by these trimer $S=1/2$ moments would then determine the magnetic properties. While theoretically isolated 2D systems with continuous symmetry suffer from Mermin-Wagner's

theorem forbidding order at finite temperature, layered compounds with spin orbit coupling are expected and observed to be only mildly sensitive to interlayer couplings in their ordering temperature. Going from $\text{Ba}_4\text{Ir}_3\text{O}_{10}$ to BaIrO_3 by adding interlayer couplings could conceivably increase the ordering temperature as long as the new out-of-plane exchanges were, unlike the in-plane exchanges, completely unfrustrated; but even so the interlayer couplings should never produce a factor of a thousand ($183\text{K}/0.2\text{K} = 915$) increase in the ordering temperature. The thousand-fold difference in frustration between the compounds, just by adding connectivity between trimer units, implies that the conventional picture based on trimers as the basic unit must be incorrect for these two compounds.



Supplementary Fig.8. Temperature dependence of magnetization M for the sister compound BaIrO_3 for comparison. Inset: the crystal structure of BaIrO_3 . The sharp transition at $T_N = 183\text{ K}$ in BaIrO_3 is three orders of magnitude higher than that in $\text{Ba}_4\text{Ir}_3\text{O}_{10}$.

Supplementary Isothermal Magnetization of $Ba_4Ir_3O_{10}$



Supplementary Fig. 9. Isothermal magnetization M at 2 K for $Ba_4Ir_3O_{10}$.

The isothermal magnetization was measured at 2 K, indicating a large magnetic anisotropy, and a weak field dependence, as shown in **Supplementary Fig.9**.

Supplementary Numerical Data Points of Magnetization

The following are the data points:

$H(T)$, $T(K)$, M_a (Bohr/Ir)

0.0000 2.0114 -2.4500e-05

0.050000 2.0084 0.00062700

0.10000 1.9922 0.0010300

0.15000 2.0003 0.0013600

0.20000 1.9966 0.0016700

0.25000 1.9925 0.0019700

0.30000 1.9756 0.0022600

0.35000 1.9780 0.0025500

0.40000 1.9992 0.0028100

0.45000	2.0019	0.0031000
0.50000	2.0026	0.0033800
0.55000	2.0011	0.0036500
0.60000	2.0019	0.0039200
0.65000	2.0026	0.0042000
0.70000	2.0022	0.0044500
0.75000	2.0028	0.0047000
0.80000	2.0019	0.0049500
0.85000	2.0023	0.0051800
0.90000	2.0020	0.0054200
0.95000	2.0021	0.0056600
1.0000	2.0022	0.0058800
1.2000	2.0028	0.0067500
1.4000	2.0031	0.0075500
1.6000	2.0032	0.0082200
1.8000	2.0027	0.0091700
2.0000	2.0036	0.0097400
2.2000	2.0027	0.010580
2.4000	2.0037	0.010990
2.6000	2.0024	0.011420
2.8000	2.0034	0.011890
3.0000	2.0025	0.012530
3.5000	2.0012	0.013690

4.0000 2.0025 0.014600

4.5000 2.0033 0.015550

5.5000 2.0032 0.017110

6.0000 2.0034 0.017670

6.5000 2.0028 0.018130

7.0000 2.0029 0.018770

H(T), T(K), Mb (Bohr magneton/Ir)

0.0000 2.0107 -2.5500e-05

0.050000 2.0006 0.00082600

0.10000 1.9965 0.0015900

0.15000 2.0010 0.0023300

0.20000 2.0013 0.0030500

0.25000 2.0011 0.0037600

0.30000 2.0001 0.0044600

0.35000 2.0008 0.0051400

0.40000 2.0008 0.0058000

0.45000 2.0015 0.0064600

0.50000 2.0021 0.0071000

0.55000 2.0010 0.0077300

0.60000 2.0008 0.0083400

0.65000 2.0009 0.0089400

0.70000 2.0014 0.0095200

0.75000	2.0000	0.010090
0.80000	2.0022	0.010640
0.85000	2.0016	0.011200
0.90000	2.0021	0.011740
0.95000	2.0003	0.012270
1.0000	1.9999	0.012780
1.2000	2.0014	0.014730
1.4000	2.0026	0.016540
1.6000	2.0011	0.018220
1.8000	2.0012	0.019750
2.0000	2.0008	0.021190
2.2000	2.0008	0.022560
2.4000	2.0022	0.023840
2.6000	2.0010	0.025000
2.8000	2.0004	0.026020
3.0000	2.0011	0.027170
3.5000	2.0012	0.029450
4.0000	2.0016	0.031560
4.5000	2.0019	0.033280
5.0000	2.0014	0.034800
6.0000	2.0013	0.037460
6.5000	2.0030	0.038550
7.0000	1.9990	0.039580

H(T), T(K), Mb (Bohr magneton/Ir)

0.0000 2.0178 -2.6400e-05

0.050000 1.9985 0.0010700

0.10000 1.9933 0.0021300

0.15000 2.0011 0.0031600

0.20000 2.0020 0.0041800

0.25000 2.0022 0.0051700

0.30000 1.9989 0.0061700

0.35000 2.0000 0.0071300

0.40000 2.0005 0.0080800

0.45000 2.0000 0.0090100

0.50000 2.0005 0.0099200

0.55000 2.0005 0.010800

0.60000 2.0001 0.011680

0.65000 1.9992 0.012550

0.70000 2.0006 0.013380

0.75000 2.0013 0.014190

0.80000 2.0004 0.014970

0.85000 1.9998 0.015760

0.90000 2.0011 0.016530

0.95000 2.0005 0.017300

1.0000 2.0004 0.018040

1.2000	2.0001	0.020850
1.4000	1.9995	0.023460
1.6000	2.0015	0.025890
1.8000	2.0002	0.028120
2.0000	2.0004	0.030280
2.2000	2.0001	0.032160
2.4000	2.0018	0.034000
2.6000	1.9999	0.035700
2.8000	1.9998	0.037260
3.0000	2.0013	0.038760
3.5000	2.0012	0.041980
4.0000	2.0013	0.044760
4.5000	1.9995	0.046900
5.0000	2.0007	0.049120
5.5000	2.0009	0.050920
6.0000	2.0007	0.052480
6.5000	1.9999	0.053810
7.0000	2.0007	0.054580

Supplementary data of magnetic susceptibility of $Ba_4Ir_3O_{10}$

The data in Fig.2b in the main text are fit to the Curie-Weiss law in form of $\Delta\chi^{-1} = (T+\theta)/C$
 $= \theta_{CW}/C + T/C$, where θ_{CW} is the Curie-Weiss temperature and C is the Curie constant. The
 Supplementary Table II below lists all constants for each fit.

Please note that the fitting parameters $m1 = \theta_{CW}/C$ and $m2 = 1/C$. The temperature range for all fits is consistently 100 – 350 K.

Supplementary Table IV Curie-Weiss Fitting Parameters

Orientation	m1	m2	C	θ_{CW} (K)
a axis	641.11	0.83652	1.1954	766.42
b axis	1650.1	4.2271	0.2365	390.37
c axis	2872.9	16.968	0.0589	169.31

H(T), T(K), Ma, χ_a

1.0000	1.7891	0.019060	0.010650
1.0000	2.3067	0.016690	0.0093300
1.0000	2.8027	0.015020	0.0083900
1.0000	3.3045	0.013650	0.0076200
1.0000	3.8215	0.012410	0.0069300
1.0000	4.3065	0.011480	0.0064100
1.0000	4.8065	0.010670	0.0059600
1.0000	5.3027	0.0099800	0.0055800
1.0000	5.8061	0.0093700	0.0052400
1.0000	6.3057	0.0088300	0.0049300
1.0000	6.8073	0.0083400	0.0046600
1.0000	7.2999	0.0079000	0.0044100
1.0000	7.8058	0.0075200	0.0042000
1.0000	8.3055	0.0071900	0.0040200
1.0000	8.8037	0.0068900	0.0038500

1.0000	9.3053	0.0066200	0.0037000
1.0000	9.8091	0.0063800	0.0035600
1.0000	10.306	0.0061500	0.0034400
1.0000	10.804	0.0059400	0.0033200
1.0000	11.997	0.0055000	0.0030700
1.0000	14.916	0.0046700	0.0026100
1.0000	19.732	0.0039000	0.0021800
1.0000	19.981	0.0038800	0.0021700
1.0000	19.995	0.0038900	0.0021700
1.0000	19.985	0.0038800	0.0021700
1.0000	19.990	0.0038800	0.0021700
1.0000	20.002	0.0038800	0.0021700
1.0000	20.000	0.0038800	0.0021700
1.0000	24.988	0.0033800	0.0018900
1.0000	31.954	0.0029200	0.0016300
1.0000	36.900	0.0027100	0.0015200
1.0000	41.896	0.0025600	0.0014300
1.0000	47.039	0.0024300	0.0013600
1.0000	55.996	0.0022700	0.0012700
1.0000	59.867	0.0022200	0.0012400
1.0000	63.639	0.0021800	0.0012200
1.0000	67.798	0.0021400	0.0012000
1.0000	75.371	0.0020900	0.0011700

1.0000	79.315	0.0020700	0.0011500
1.0000	84.596	0.0020500	0.0011400
1.0000	90.076	0.0020200	0.0011300
1.0000	94.027	0.0020100	0.0011200
1.0000	97.986	0.0020000	0.0011200
1.0000	105.46	0.0019800	0.0011000
1.0000	109.33	0.0019700	0.0011000
1.0000	113.31	0.0019600	0.0010900
1.0000	117.33	0.0019400	0.0010800
1.0000	122.18	0.0019300	0.0010800
1.0000	129.74	0.0019000	0.0010600
1.0000	133.73	0.0019000	0.0010600
1.0000	137.72	0.0019000	0.0010600
1.0000	141.93	0.0018800	0.0010500
1.0000	149.49	0.0018700	0.0010400
1.0000	153.69	0.0018600	0.0010400
1.0000	157.66	0.0018500	0.0010300
1.0000	162.24	0.0018100	0.0010100
1.0000	169.58	0.0018100	0.0010100
1.0000	173.47	0.0018000	0.0010100
1.0000	177.83	0.0017500	0.00097900
1.0000	182.00	0.0018000	0.0010000
1.0000	190.13	0.0017600	0.00098300

1.0000	193.95	0.0017500	0.00097600
1.0000	197.78	0.0017400	0.00097400
1.0000	201.91	0.0017300	0.00096900
1.0000	210.05	0.0017100	0.00095600
1.0000	213.93	0.0017000	0.00095200
1.0000	217.66	0.0017000	0.00094800
1.0000	222.41	0.0016900	0.00094400
1.0000	230.44	0.0016700	0.00093500
1.0000	234.28	0.0016700	0.00093200
1.0000	238.49	0.0016600	0.00092600
1.0000	242.66	0.0016500	0.00092300
1.0000	250.42	0.0016300	0.00091300
1.0000	254.38	0.0016300	0.00090800
1.0000	258.11	0.0016200	0.00090400
1.0000	262.23	0.0016100	0.00089700
1.0000	270.64	0.0015700	0.00087900
1.0000	276.67	0.0015600	0.00087400
1.0000	280.52	0.0015600	0.00087000
1.0000	284.29	0.0015500	0.00086600
1.0000	288.24	0.0015400	0.00086200
1.0000	295.59	0.0015300	0.00085300
1.0000	299.40	0.0015200	0.00085100
1.0000	303.43	0.0015200	0.00084700

1.0000	307.29	0.0015100	0.00084200
1.0000	315.98	0.0015000	0.00083900
1.0000	320.07	0.0014900	0.00083100
1.0000	324.27	0.0014800	0.00082500
1.0000	328.45	0.0014700	0.00082200
1.0000	332.33	0.0014700	0.00081800
1.0000	339.86	0.0014500	0.00081100
1.0000	343.86	0.0014600	0.00081500
1.0000	347.81	0.0014500	0.00081300
1.0000	350.09	0.0014500	0.00081200

H(T), T(K), M_b, χ_b

1.0000	1.7843	0.013510	0.0075500
1.0000	1.7902	0.013490	0.0075300
1.0000	2.3079	0.011590	0.0064700
1.0000	2.8053	0.010270	0.0057400
1.0000	3.3023	0.0092200	0.0051500
1.0000	3.8137	0.0083000	0.0046400
1.0000	4.3082	0.0076200	0.0042500
1.0000	4.8105	0.0070200	0.0039200
1.0000	5.2918	0.0065700	0.0036700
1.0000	5.8077	0.0061000	0.0034100
1.0000	6.2892	0.0057400	0.0032100

1.0000	6.8051	0.0054700	0.0030500
1.0000	7.3054	0.0051800	0.0028900
1.0000	7.8042	0.0048800	0.0027300
1.0000	8.3034	0.0046800	0.0026200
1.0000	8.8062	0.0044700	0.0025000
1.0000	9.3068	0.0042700	0.0023900
1.0000	9.8038	0.0041200	0.0023000
1.0000	10.305	0.0040000	0.0022400
1.0000	10.808	0.0038800	0.0021700
1.0000	11.997	0.0035700	0.0020000
1.0000	14.914	0.0030700	0.0017100
1.0000	18.800	0.0027000	0.0015100
1.0000	19.979	0.0025900	0.0014500
1.0000	19.992	0.0026000	0.0014500
1.0000	20.004	0.0026000	0.0014500
1.0000	19.994	0.0025800	0.0014400
1.0000	19.978	0.0026000	0.0014500
1.0000	19.995	0.0025900	0.0014500
1.0000	24.979	0.0023200	0.0013000
1.0000	31.946	0.0020300	0.0011400
1.0000	37.026	0.0019100	0.0010700
1.0000	42.185	0.0017800	0.00099200
1.0000	47.072	0.0017500	0.00097600

1.0000	54.468	0.0016500	0.00092300
1.0000	58.176	0.0016000	0.00089400
1.0000	61.967	0.0016000	0.00089100
1.0000	67.082	0.0015700	0.00087400
1.0000	75.108	0.0015200	0.00084600
1.0000	79.232	0.0015000	0.00083500
1.0000	83.190	0.0014700	0.00082400
1.0000	87.294	0.0014600	0.00081600
1.0000	94.749	0.0014600	0.00081600
1.0000	98.861	0.0014300	0.00080100
1.0000	103.05	0.0014400	0.00080300
1.0000	107.33	0.0013800	0.00077300
1.0000	114.98	0.0014200	0.00079500
1.0000	118.85	0.0013900	0.00077800
1.0000	123.10	0.0014100	0.00078500
1.0000	127.10	0.0013700	0.00076400
1.0000	135.10	0.0013800	0.00077100
1.0000	139.20	0.0014000	0.00078300
1.0000	143.25	0.0013500	0.00075200
1.0000	147.27	0.0013600	0.00076200
1.0000	155.34	0.0013600	0.00076000
1.0000	159.26	0.0013500	0.00075600
1.0000	163.32	0.0013400	0.00074900

1.0000	167.14	0.0013100	0.00073200
1.0000	175.01	0.0013100	0.00073100
1.0000	178.95	0.0013300	0.00074300
1.0000	183.04	0.0013000	0.00072700
1.0000	187.52	0.0013000	0.00072400
1.0000	192.11	0.0013100	0.00073300
1.0000	199.84	0.0012900	0.00072200
1.0000	203.97	0.0012900	0.00071900
1.0000	208.36	0.0012600	0.00070500
1.0000	212.10	0.0012500	0.00069600
1.0000	219.85	0.0012700	0.00070700
1.0000	223.69	0.0012400	0.00069100
1.0000	227.43	0.0012800	0.00071400
1.0000	232.26	0.0012600	0.00070200
1.0000	241.55	0.0012200	0.00068000
1.0000	245.57	0.0012400	0.00069000
1.0000	249.72	0.0012500	0.00069800
1.0000	253.81	0.0012300	0.00068500
1.0000	257.79	0.0012200	0.00068000
1.0000	265.17	0.0012300	0.00068900
1.0000	268.97	0.0011900	0.00066500
1.0000	272.98	0.0012100	0.00067800
1.0000	277.43	0.0011900	0.00066700

1.0000	284.81	0.0011900	0.00066500
1.0000	288.50	0.0012200	0.00068200
1.0000	292.32	0.0011800	0.00066200
1.0000	297.00	0.0011700	0.00065600
1.0000	305.08	0.0011700	0.00065400
1.0000	308.97	0.0011700	0.00065100
1.0000	313.08	0.0011500	0.00064400
1.0000	317.21	0.0011600	0.00064900
1.0000	325.26	0.0011600	0.00064600
1.0000	329.46	0.0011600	0.00064800
1.0000	333.30	0.0011400	0.00063900
1.0000	337.23	0.0011700	0.00065500
1.0000	341.89	0.0011700	0.00065300
1.0000	349.44	0.0011200	0.00062700
1.0000	350.06	0.0011600	0.00064900

H(T), T(K), M_c, χ_c

1.0000	1.7720	0.0062000	0.0034600
1.0000	1.7864	0.0061800	0.0034500
1.0000	2.3046	0.0054500	0.0030400
1.0000	2.8048	0.0049000	0.0027400
1.0000	3.3012	0.0044700	0.0025000
1.0000	3.8168	0.0041100	0.0023000

1.0000	4.3048	0.0038300	0.0021400
1.0000	4.8082	0.0036000	0.0020100
1.0000	5.3080	0.0033900	0.0019000
1.0000	5.8099	0.0032100	0.0017900
1.0000	6.3084	0.0030500	0.0017000
1.0000	6.8079	0.0029000	0.0016200
1.0000	7.3032	0.0027800	0.0015500
1.0000	7.8038	0.0026600	0.0014900
1.0000	8.3052	0.0025700	0.0014300
1.0000	8.8058	0.0024700	0.0013800
1.0000	9.3038	0.0023900	0.0013400
1.0000	9.8054	0.0023200	0.0013000
1.0000	10.304	0.0022400	0.0012500
1.0000	10.805	0.0021800	0.0012200
1.0000	11.996	0.0020400	0.0011400
1.0000	15.149	0.0017700	0.00099100
1.0000	18.718	0.0015900	0.00089000
1.0000	19.976	0.0015500	0.00086600
1.0000	19.990	0.0015600	0.00087200
1.0000	20.003	0.0015500	0.00086500
1.0000	19.995	0.0015500	0.00086500
1.0000	19.982	0.0015600	0.00087000
1.0000	19.995	0.0015500	0.00086500

1.0000	24.969	0.0013900	0.00077800
1.0000	32.043	0.0012400	0.00069500
1.0000	37.288	0.0011600	0.00065000
1.0000	41.968	0.0011300	0.00063000
1.0000	47.051	0.0010700	0.00060000
1.0000	54.218	0.0010300	0.00057600
1.0000	57.794	0.0010000	0.00056100
1.0000	62.068	0.00099200	0.00055400
1.0000	67.062	0.00096900	0.00054100
1.0000	74.855	0.00093700	0.00052300
1.0000	78.577	0.00093500	0.00052200
1.0000	83.435	0.00092100	0.00051400
1.0000	88.097	0.00090800	0.00050800
1.0000	95.727	0.00088200	0.00049300
1.0000	99.324	0.00089200	0.00049800
1.0000	103.49	0.00087800	0.00049100
1.0000	107.64	0.00087800	0.00049100
1.0000	112.04	0.00085700	0.00047900
1.0000	119.57	0.00085700	0.00047900
1.0000	124.19	0.00084600	0.00047300
1.0000	128.12	0.00085100	0.00047500
1.0000	132.59	0.00083600	0.00046700
1.0000	140.49	0.00082200	0.00045900

1.0000	144.46	0.00082900	0.00046300
1.0000	148.23	0.00081100	0.00045300
1.0000	152.34	0.00081600	0.00045600
1.0000	160.14	0.00080900	0.00045200
1.0000	163.95	0.00080300	0.00044900
1.0000	167.85	0.00080200	0.00044800
1.0000	172.10	0.00078900	0.00044100
1.0000	180.06	0.00079300	0.00044300
1.0000	183.91	0.00078700	0.00044000
1.0000	187.74	0.00078800	0.00044000
1.0000	192.06	0.00078400	0.00043800
1.0000	197.19	0.00078600	0.00043900
1.0000	204.51	0.00077100	0.00043100
1.0000	208.46	0.00076600	0.00042800
1.0000	212.59	0.00077400	0.00043200
1.0000	217.27	0.00075600	0.00042200
1.0000	224.81	0.00077100	0.00043100
1.0000	228.78	0.00075500	0.00042200
1.0000	232.71	0.00076200	0.00042600
1.0000	237.31	0.00074800	0.00041800
1.0000	245.14	0.00074600	0.00041700
1.0000	249.12	0.00074900	0.00041800
1.0000	253.18	0.00074600	0.00041700

1.0000	257.33	0.00074300	0.00041500
1.0000	264.82	0.00074200	0.00041400
1.0000	268.53	0.00074100	0.00041400
1.0000	272.58	0.00073200	0.00040900
1.0000	276.83	0.00073300	0.00041000
1.0000	284.77	0.00072600	0.00040600
1.0000	288.78	0.00072300	0.00040400
1.0000	292.79	0.00071600	0.00040000
1.0000	297.00	0.00072000	0.00040200
1.0000	305.23	0.00071600	0.00040000
1.0000	308.92	0.00070800	0.00039600
1.0000	312.83	0.00070900	0.00039600
1.0000	316.98	0.00070400	0.00039300
1.0000	321.86	0.00070800	0.00039500
1.0000	329.58	0.00069500	0.00038800
1.0000	333.44	0.00070000	0.00039100
1.0000	337.36	0.00070100	0.00039200
1.0000	342.09	0.00069300	0.00038700
1.0000	349.74	0.00068700	0.00038400
1.0000	350.05	0.00069700	0.00038900

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