Supplementary materials for ”Distinct switching of chiral transport in the kagome metals KV_3Sb_5 and CsV_3Sb_5”

Chunyu Guo*,[1] Maarten R. van Delft,[2] Martin Gutierrez-Amigo,[3,4] Dong Chen,[5,6] Carsten Putzke,[1] Glenn Wagner,[7] Mark H. Fischer,[7] Titus Neupert,[7] Ion Errea,[3,8,9] Maia G. Vergniory,[5,8] Steffen Wiedmann,[2,10] Claudia Felser,[5] and Philip J. W. Moll*[1]

[1]*Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany*

[2]*High Field Magnet Laboratory (HFML - EMFL), Radboud University, Toernooiveld 7, 6525 ED Nijmegen, The Netherlands*

[3]*Centro de Física de Materiales (CSIC-UPV/EHU), Donostia-San Sebastian, Spain*

[4]*Department of Physics, University of the Basque Country (UPV/EHU), Bilbao, Spain*

[5]*Max Planck Institute for Chemical Physics of Solids, Dresden, Germany*

[6]*College of Physics, Qingdao University, Qingdao, China*

[7]*Department of Physics, University of Zürich, Zürich, Switzerland*

[8]*Donostia International Physics Center, Donostia-San Sebastian, Spain*

[9]*Fisika Aplikatua Saila, Gipuzkoako Ingeniaritza Eskola, University of the Basque Country (UPV/EHU), Donostia-San Sebastian, Spain*

[10]*Radboud University, Institute for Molecules and Materials, Nijmegen 6525 AJ, Netherlands*

(Dated: January 19, 2024)

Supplementary Note 1: Angular dependence of magnetoresistance

The angular dependence of magnetoresistance is measured with a rotation from c to a'-axis for both CsV_3Sb_5 and KV_3Sb_5 (Supplementary Figure 1). Here θ stands for the angle between c-axis and field direction, and a' is defined as the in-plane direction perpendicular to a-axis. For the longitudinal configuration with the field applied approximately parallel to the current direction, a negative magnetoresistance (MR) is observed in CsV_3Sb_5. This is possibly due to the reduction of boundary scattering in magnetic field, as commonly seen in clean metals where the transport mean free path is comparable to the size of the microstructure. For KV_3Sb_5, the longitudinal magnetoresistance also tends to saturate at high magnetic field yet no negative MR is observed. This suggests an enhanced scattering rate in KV_3Sb_5 likely due to K-vacancies. Therefore, the quantum oscillation amplitude is also smaller in K- compared to Cs-compound, yet clear quantum oscillations can still be observed up to 75 deg for both materials.

Supplementary Note 2: FFT analysis of quantum oscillations

By subtracting the third-polynomial function as a MR background, we have obtained the SdH oscillations for various angles. After having identified all peaks in the Fast Fourier Transform analysis (Supplementary Figure 2) with the field window of 5 to 35 T, the full angular dependence of the high oscillation frequencies ($F > 500$ T) is presented in Fig. 2.

Supplementary Note 3: Angular dependence of $V_{2\omega}$

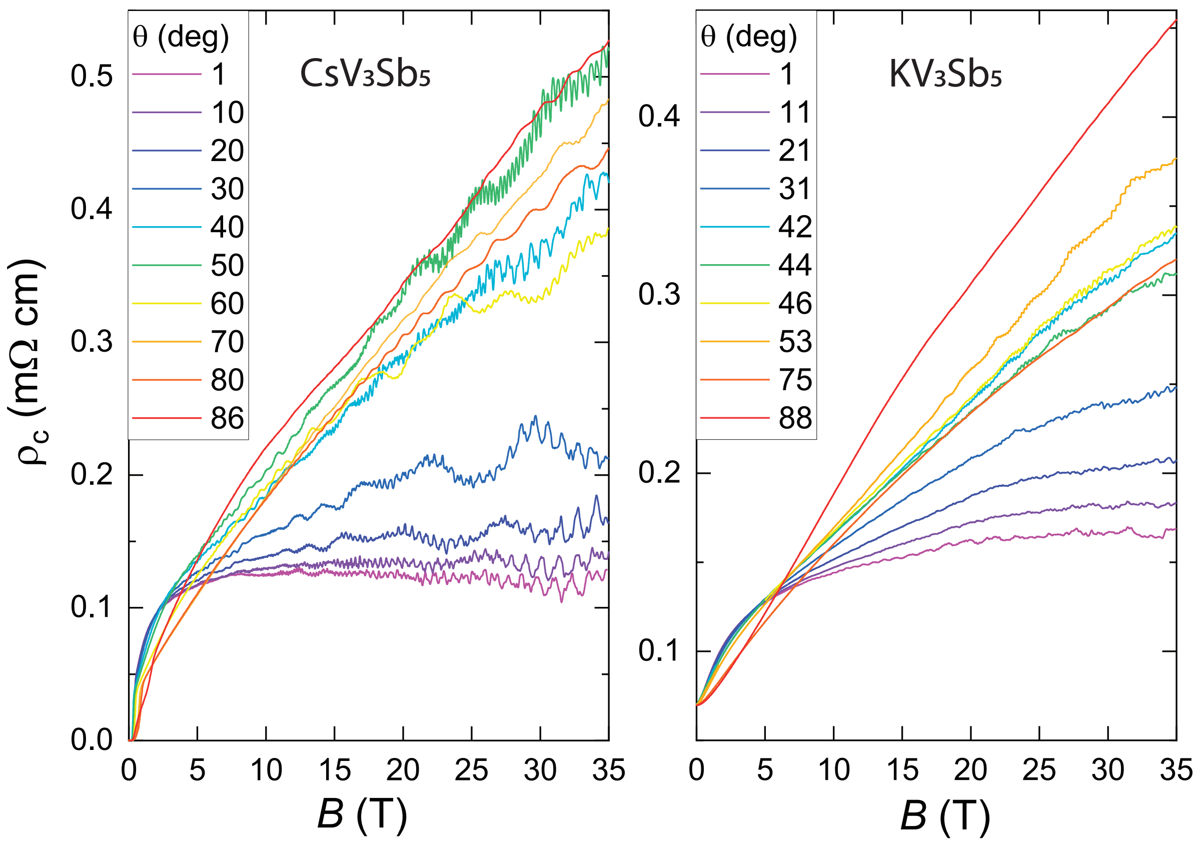
The angular dependence of the second harmonic response in CsV_3Sb_5 displays a strong spike and its sign switches when the magnetic field rotates across the Kagome plane (Supplementary Figure 3). Such enhancement is consistently observed in previous measurements and provides direct evidence of a field-switchable electronic chirality in CsV_3Sb_5. Such behavior is absent in KV_3Sb_5 as $V_{2\omega}$ as a consequence of minimized chiral transport. These results consistently demonstrate the distinct switching of chiral transport in CsV_3Sb_5 and KV_3Sb_5.

Supplementary Note 4: Heating-induced extrinsic second harmonic generation in KV_3Sb_5

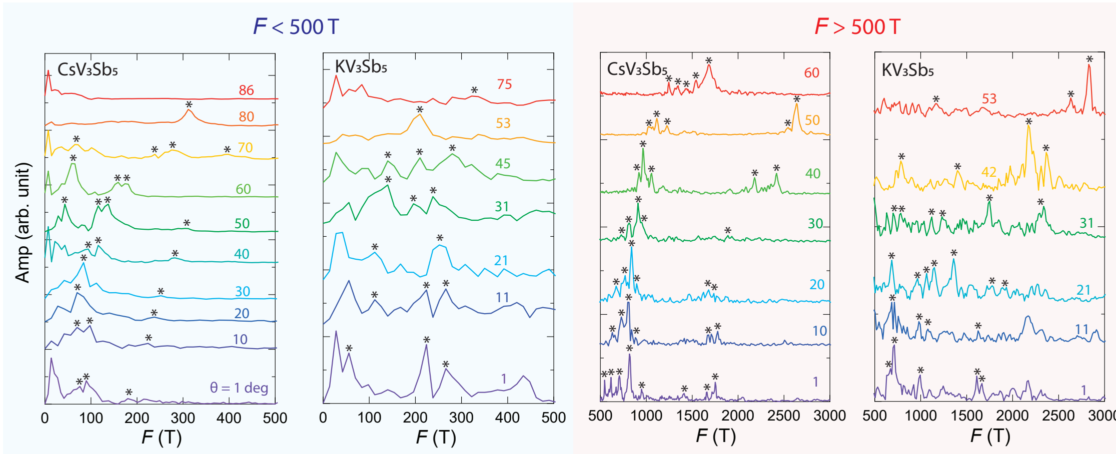
To verify the possible extrinsic origin of the second harmonic voltage generation, we have measured the device at the same temperature and field configuration yet with different thermal conditions (Supplementary Figure 4). By adding a slight amount of He^4 exchange gas to the sample chamber, the thermal link between the microstructure and the sample space is enhanced. If the second harmonic voltage we measured is completely intrinsic, this change of thermal condition shall not alter the signal at all[1]. However, a change of the signal can be observed which suggests the existence of extrinsic second harmonic voltage, most likely due to the thermal gradient across the device. This is likely due to the contact resistance difference between the two current leads. Consistently a field-symmetric component is readily observed and the signal measured at $\pm$ 35 T is differed by about 20 % for θ = -1 deg.

SUPPLEMENTARY REFERENCES

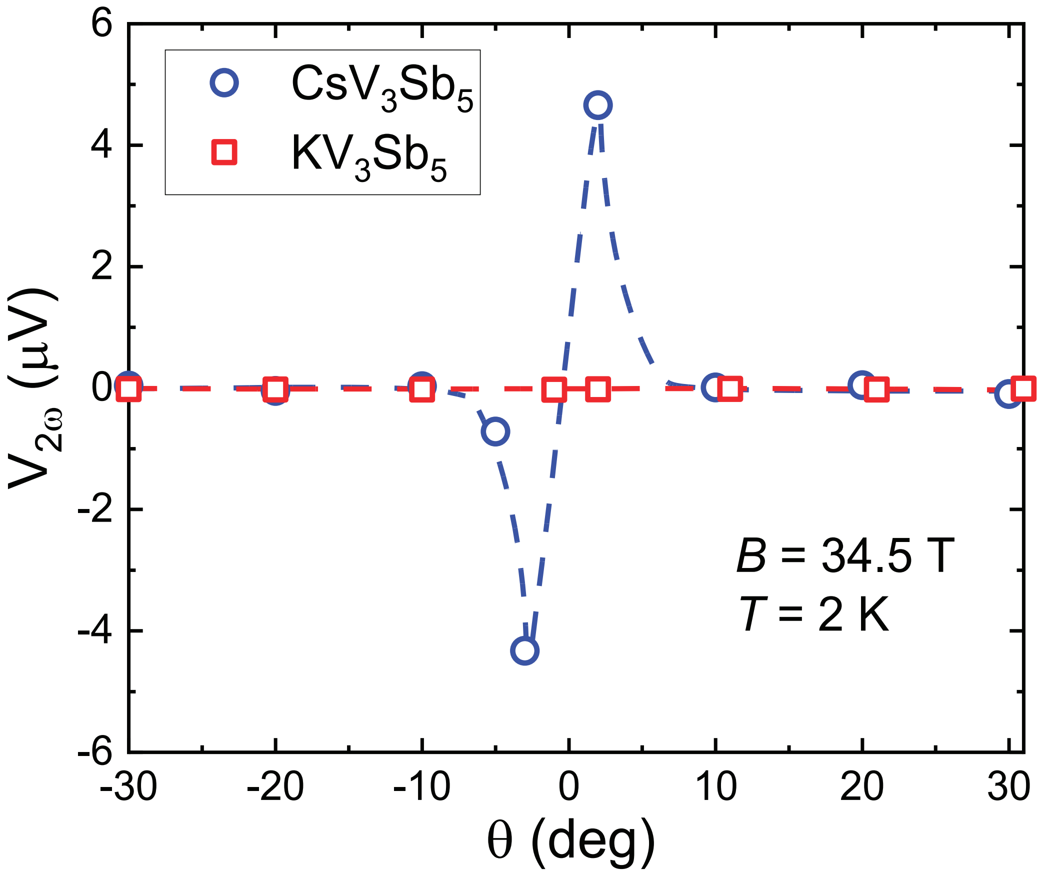
[1] C. Guo, et al., Nature **611**, 461 (2022).



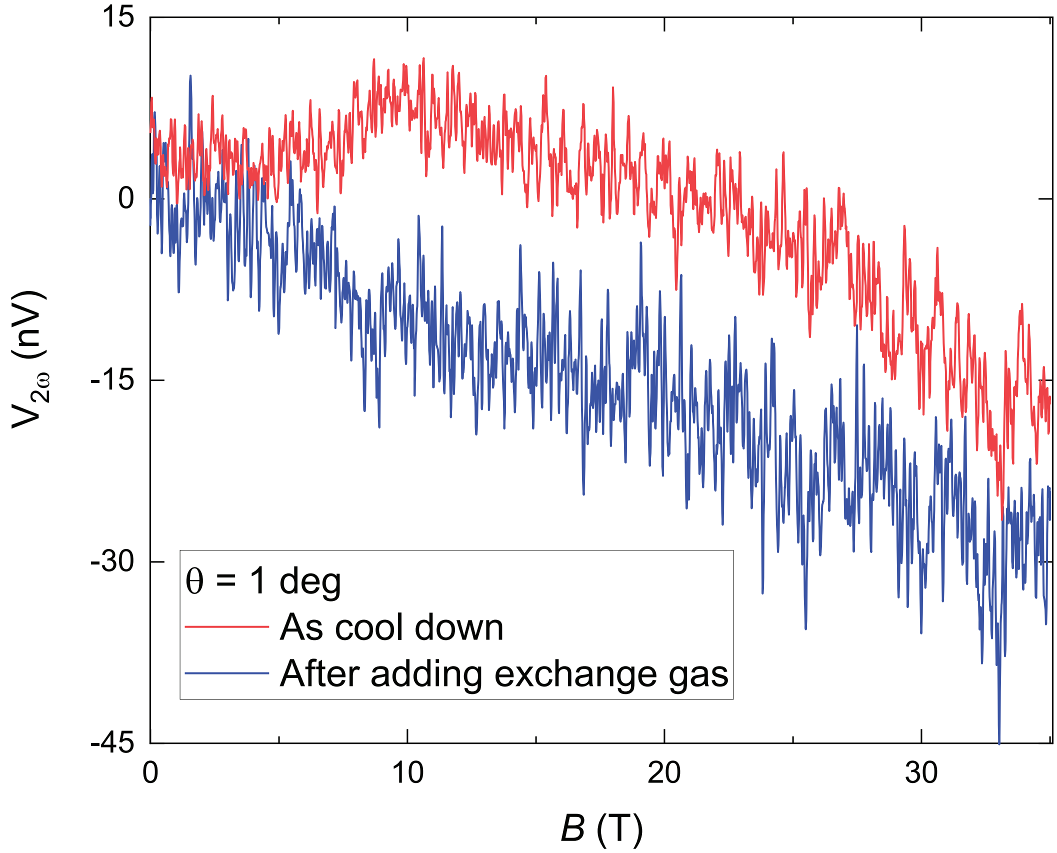
Supplementary Figure 1. **Angular dependence of magnetoresistance.** The angular magnetoresistance is measured with a field rotation from c to a'-axis and θ here stands for the angle between the field direction and c-axis. Clear quantum oscillations are readily observed in both materials, yet the amplitude is comparatively small for KV_3Sb_5 due to the reduced sample quality.



Supplementary Figure 2. **Angle-dependent FFT spectrum.** The Fast Fourier Transform (FFT) analysis of quantum oscillations at various angles allows us to identify the angular evolution of each peak. The corresponding frequencies are summarized in Fig. 2.



Supplementary Figure 3. **Angular dependence of $V_{2\omega}$.** The angular dependence of the second harmonic voltage in CsV_3Sb_5 displays a clear spike only when the field direction is close to the Kagome planes, consistent with the previous reports[1]. Such behavior is not observed in KV_3Sb_5 as the second harmonic signal remains unchanged with varying θ.



Supplementary Figure 4. **Origin of extrinsic second harmonic voltage generation.** The field-dependence of $V_{2\omega}$ has been measured with two different thermal conditions. By adding more exchange gas to the sample space, the signal is significantly altered, suggesting Joule heating as the origin of the observed second harmonic signal.