Probing thermoelectric effects in $MnBi_2Te_4$

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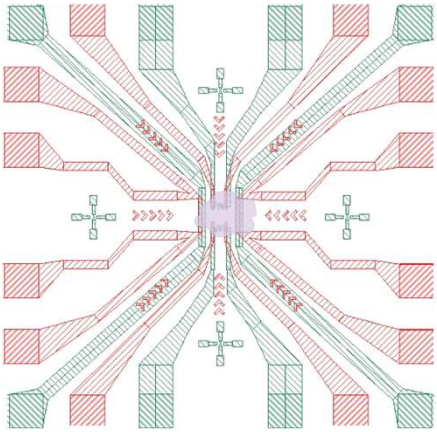
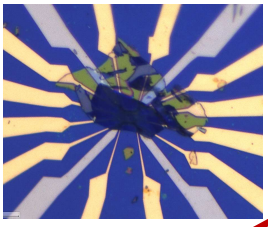
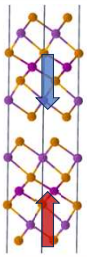
Experiment



- Al_2O_3 assisted exfoliation of MnBi2Te4 down to 6-7 layers
- Buried micro-heaters provide the thermal gradient
- Evaporated Al_2O_3 is used as a dielectric between the heater and contact leads
- Hall bar geometry + 4 contacts drain and source for resistive thermometry



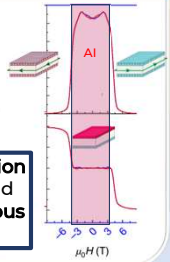
Material : $MnBi_2Te_4$



- First synthetised **intrinsic magnetic topological insulator** (2020)
- A-type antiferromagnetic semiconductor ($T_{Néel} = 25K$)
- Air sensible

Te
Bi
Mn

Was shown to host **axion insulator** (Al) state and the **quantum anomalous Hall effect** (QAHE)

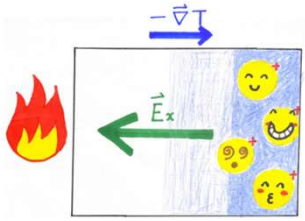


Liu, C. et al. Nature Materials 19, 1–6 (2020).

Thermoelectric effects

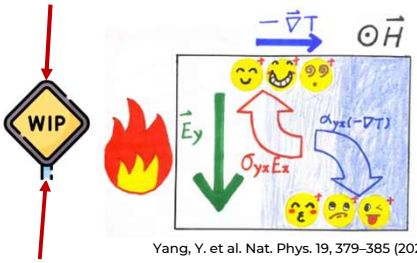
Seebeck $\vec{E} \parallel \overrightarrow{\nabla T}$ = Longitudinal

- Thermally excited electrons tend to accumulate near the cold lead, creating a Seebeck voltage



Nernst $\vec{E} \parallel \vec{B} \times \overrightarrow{\nabla T}$ = Transverse

- The Nernst effect creates a Nernst voltage transverse to the thermal gradient
- The effect scales linearly with $\vec{B}$ and $\overrightarrow{\nabla T}$



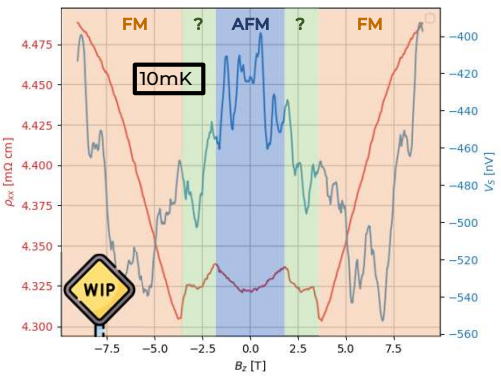
Yang, Y. et al. Nat. Phys. 19, 379–385 (2023).

Anomalous Nernst effect (ANE)

- Anomalous = Component at 0T
- The Berry curvature acts as a magnetic field in the $\vec{k}$ space
- A topological material is a material in which a band inversion creates a non-trivial Berry curvature

➔ **$MnBi_2Te_4$ is predicted to host an important ANE**

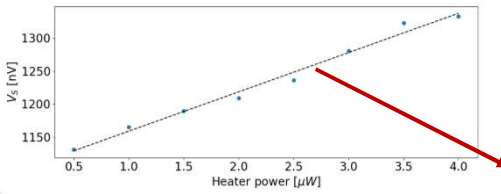
Experimental results



AFM : Inter-layer coupling is suppressed in the AFM state
? : Likely a spin-canted state, the inter-layer coupling is gradually restored
FM : The spins are aligned, the material is n-doped and thus a negative MR is observed

- Features of the MR are reproduced in the thermovoltage signal

➔ **How does the magnetism influence the thermoelectric properties ?**

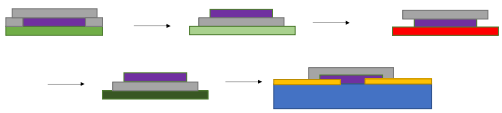


- The intermediate region presents extra features that are absent from literature

➔ **Can it be described by a spin-canted model ?**

V_S scales linearly with the heating power ✓

Sample fabrication



Performed inside a N2-filled glovebox

Scotch tape
$MnBi_2Te_4$ flake
Al_2O_3
Thermal release tape
PDMS
PPC
Gold/graphene contact
285nm oxidised Si

Next steps

- **Revealing topological features** (axion insulator, QAHE...) by gating to the charge neutrality point
- **Investigating unknown features** in the MR trace
- **Local characterisation of thermoelectric properties** with a homemade cryogenic SThM set-up
- **Interfacing $MnBi_2Te_4$ with 2D magnets** : new control knob on thermoelectric properties

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