Local Magnetic Properties of a Topological Insulator $MnBi_2Te_4$

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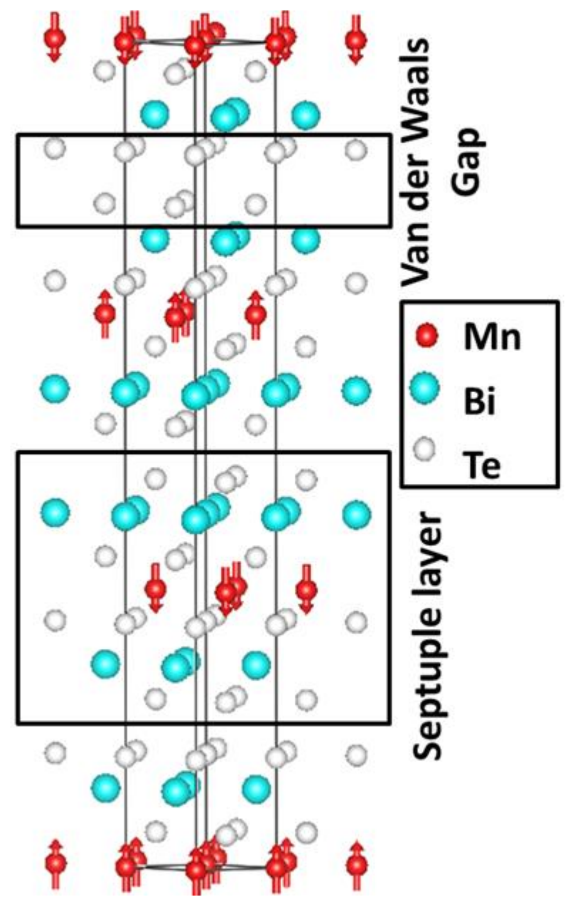
Introduction

Topological insulators are materials that reveal metallic, topologically protected states at their surface, while in the bulk, they remain insulating. Those quantum surface states bring the possibility of new applications in spintronics and quantum computing. In the last decade magnetic topological insulators have attracted a substantial research interest due to the potential for attaining exotic topological quantum states, such as Quantum Anomalous Hall Effect (QAHE). The realization of QAHE without external magnetic field may pave the way to the development of low-power-consumption devices and this has been already theoretically predicted in the first intrinsic magnetic topological insulator $MnBi_2Te_4$.



$MnBi_2Te_4$ – AFM with T_N = 24 K

What is the low temperature local magnetic moment of Mn atoms?

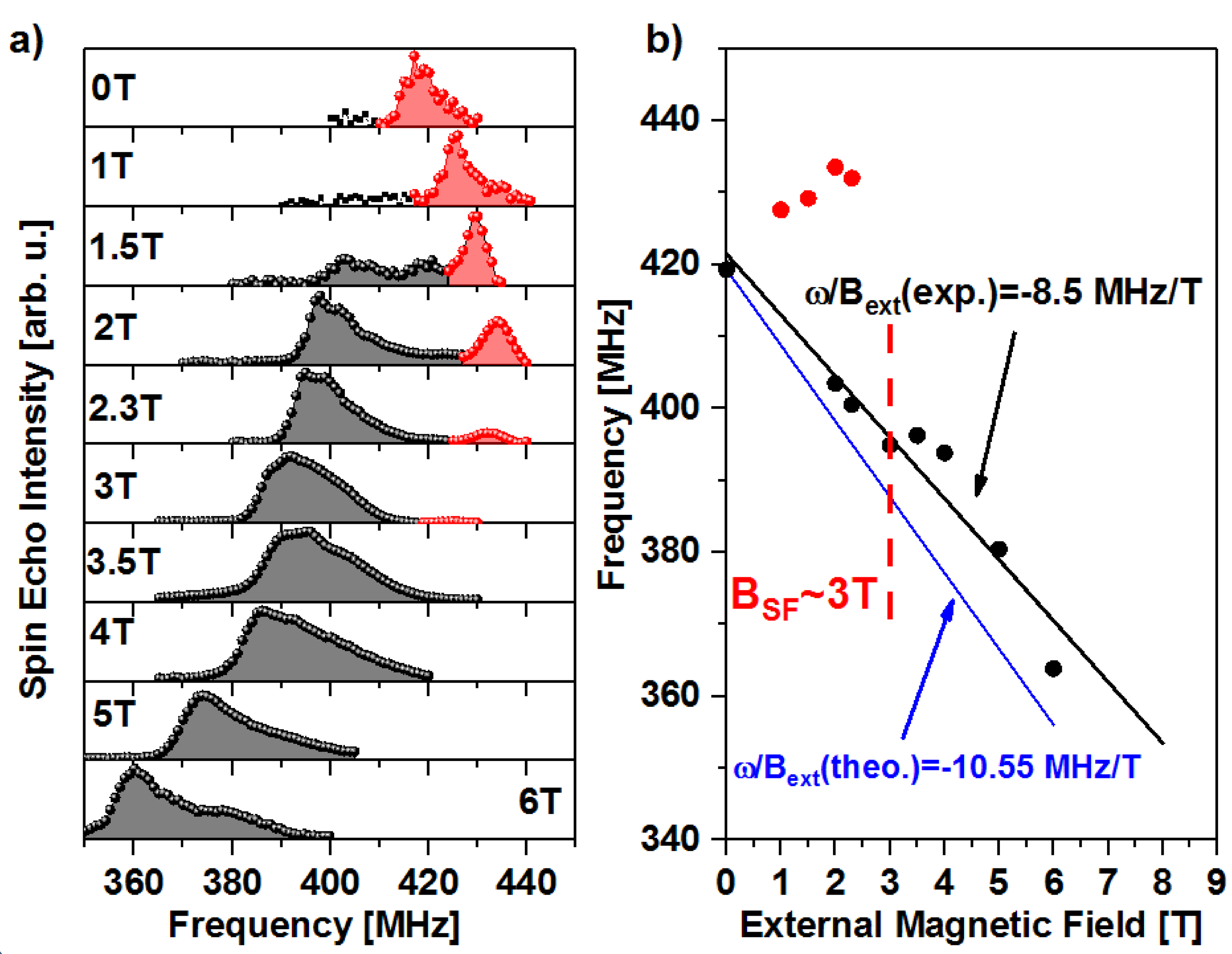
$1.14\ \mu_B$
[Y. Gong et al. Chin. Phys. Lett. **36,** (2019) 076801]

$3.56\ \mu_B$
[J.-Q. Yan et al. Phys. Rev. B, **100,** (2019) 104409]

$4.04\ \mu_B$
[J.-Q. Yan et al. Phys. Rev. Mat **3,** (2019) 064202]

$5\ \mu_B$
[M. M. Otrokov et al. Nature. **576,** (2019) 416]

^{55}Mn NMR in the external magnetic field applied along c-axis (easy direction) at 4.2 K



$$\omega = \gamma B_{eff}$$

$$B_{eff} \approx B_{hf} \sim A\mu$$

Zero Field:

$\omega = 419.32\ MHz$

$\gamma(^{55}Mn) = 10.55\ MHz/T$

$B_{eff} = 39.75\ T$

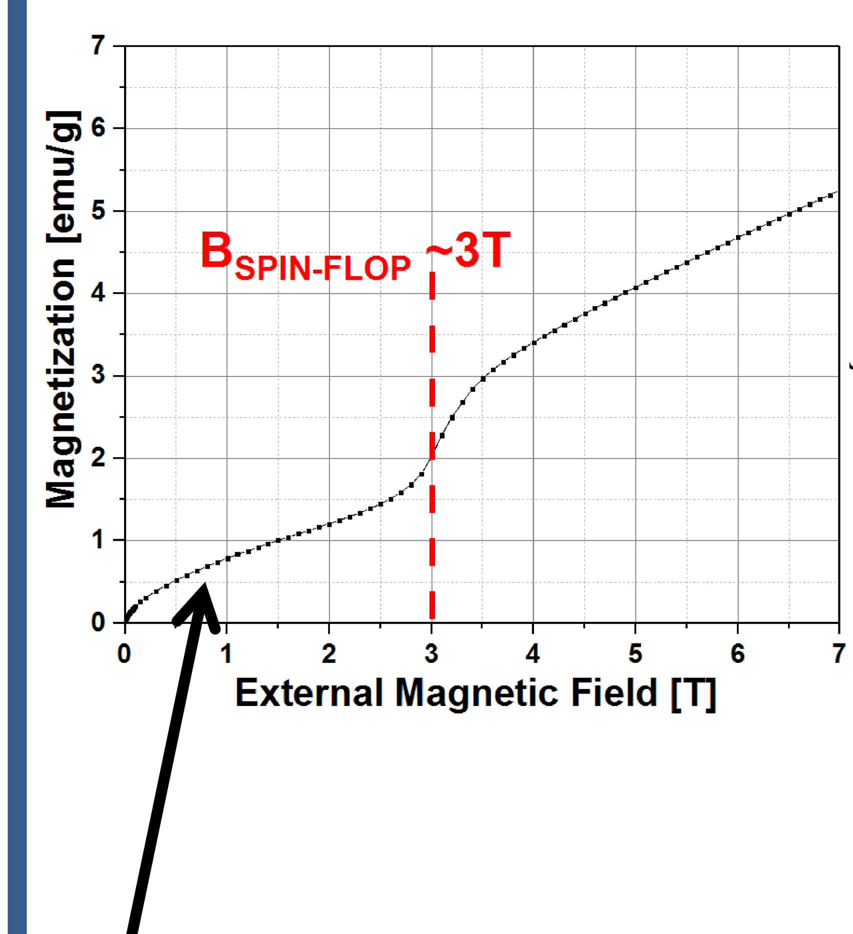
$A = 12\ T/\mu_B$

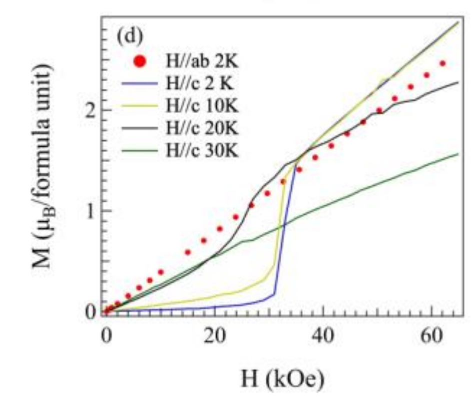
S. Picozzi et al. Phys. Rev. B. **70,** (2004) 235205

Estimated Mn magnetic moment

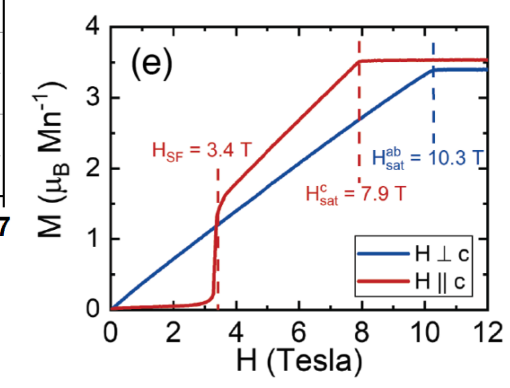
$\mu_{Mn} \approx 3.3\mu_B$

Magnetization vs external magnetic field along c-axis at 4 K





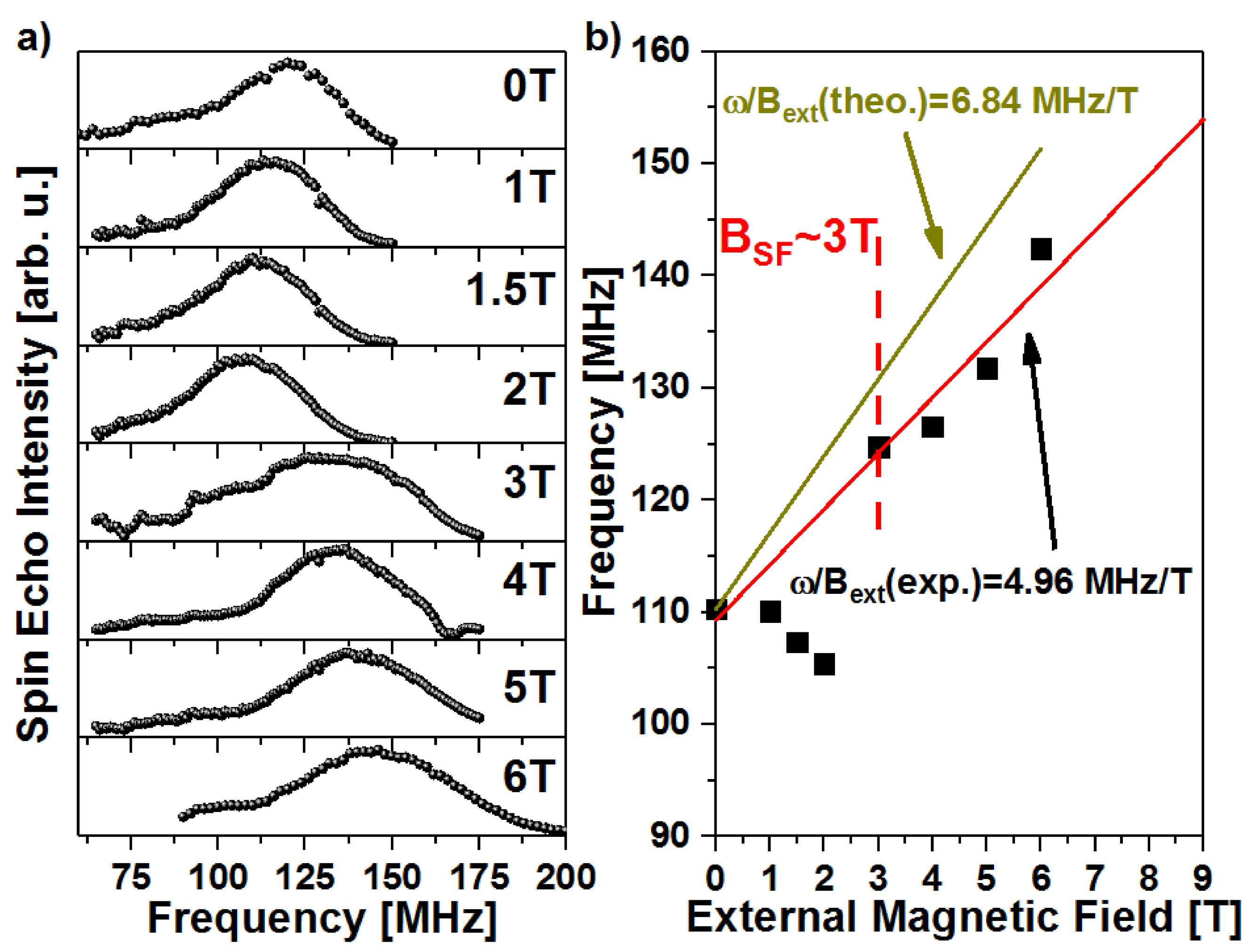
J.-Q. Yan. Et al. Phys. Rev. Mat. **3,** (2019) 064202



B. Li et al. Phys. Rev. Lett. **124,** (2020) 167204

Non-zero magnetic response of the system below SF transition. B_{SF} (~3T) in agreement with the values already reported in literature.

^{209}Bi NMR in the external magnetic field applied along c-axis (easy direction) at 4.2 K



Zero Field:

$\omega = 110.29\ MHz$

$\gamma(^{209}Bi) = 6.84\ MHz/T$

$B_{eff} = 16.12\ T$

Supertransferred hyperfine field at ^{209}Bi nuclei sites due to the strong spin polarization of the valence electron shell of bismuth set by uncompensated Mn magnetic moments.

Conclusions

- **We found resonance frequency of ^{55}Mn nuclei to be 419.32 MHz. Based on this value we estimated the local magnetic moment of Mn atoms in $MnBi_2Te_4$ to be $\mu_{Mn} \approx 3.3\ \mu_B$.**
- **We found resonance frequency of ^{209}Bi nuclei to be 110.29 MHz, corresponding to the effective magnetic field at ^{209}Bi nuclei 16.12 T. While bismuth is nonmagnetic, the observed NMR signal originating from ^{209}Bi nuclei sites must come from supertransferred and transferred hyperfine field introduced by Mn atoms with non-zero magnetic moments.**
- **Non-zero magnetization in the M vs B curve in AFM $MnBi_2Te_4$ and the observed NMR signal below spin-flop transition ($B_{SF} \sim 3\ T$) indicate the presence of uncompensated, ferromagnetic component in the sample, possibly related to Mn/Bi intermixing defects.**

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