Role of anti-site intermixing in the magnetic structure of intrinsic magnetic topological insulator: $Mn_{1\pm x}Sb_{2\pm x}Te_4$

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Time-reversal symmetry breaking in a topological insulator (TI) opens a surface gap and distinguishes chiral quantum states that could eventually be exploited in electrically controlled spintronic devices. The new approach to create this state in a TI is with the intrinsic magnetic proximity of a magnetic insulator that can be achieved with layered van der Waals materials. Soon after the exploration of antiferromagnetic $MnBi_2Te_4$ its isostructural sister compound $MnSb_2Te_4$ gained popularity because of its high transition temperature and possible ferromagnetic interlayer interaction between the septuple layers, resulting in a remnant magnetic moment without the application of a magnetic field [1]. Additionally,recent combined spin- and angle-resolved photoemission spectroscopy and scanning tunneling microscopy studies on epitaxial high-Tc $MnSb_2Te_4$ film pinned down a non-trivial band topology, essential for the Quantum anomalous hall effect in this compound [1]. Both, experimental and theoretical investigations have separately revealed that the magnetic and electronic topological state strongly depends on the amount and type of anti-site intermixing and/or Mn content in these layered van-der-Waals compounds [2]. In our joint bulk magnetic and local spectroscopic experimental study, we investigate the effect of such intermixing on the magnetic properties of $Mn_{1\pm x}Sb_2Te_4$ single crystals and powders. We combine Nuclear Magnetic Resonance (NMR), and Muon Spin Relaxation(μSR), with bulk SQUID magnetometry to reveal the local magnetic properties of the Mn ions. Our single crystal studies are in accordance with the ferrimagnetic state of our $Mn_{1+x}Sb_2Te_4$ single crystals with a high amount of anti-site intermixing as well as with frozen spin clusters just below the ordering temperature. NMR on powder samples clearly indicates the intermixing of Mn/Sb on their respective sites and the Mn at 3a and 6c positions are aligned in the opposite direction which gives rise to an overall ferrimagnetic behavior as suggested by bulk magnetometry. Zero-field μSR shows an overall broad distribution of magnetic field at the muon position due to the site intermixing. However, the weak transverse field shows a sharp magnetic transition, taking place in the whole volume of the material.
In light of our results, the role of anti-sites in the magnetic structures is discussed, as well as new perspectives for this family of materials.

References

[1] Wimmer et al., Adv.Mater. (2021) 33, 2102935
[2] Liu et al., Physical Review X (2021) 11, 021033