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STUDY OF MBE GROWTH AND THERMAL STABILITY OF Bi_2MnTe_4 THIN FILMS

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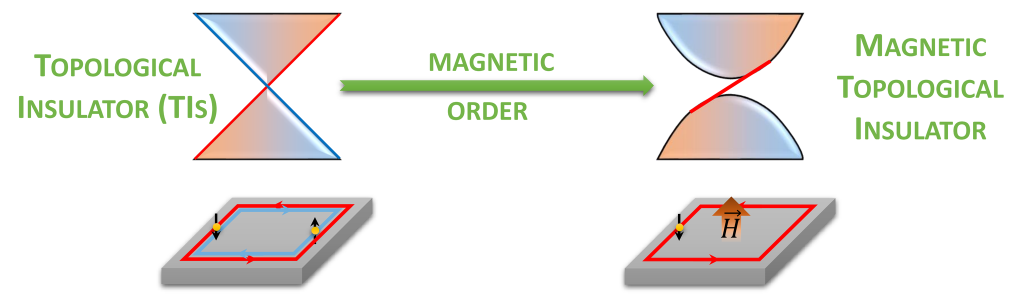
INTRODUCTION



Quantized magnetoelectric coupling · Axion electrodynamics · Quantum anomalous Hall effect · Chiral Majorana fermions

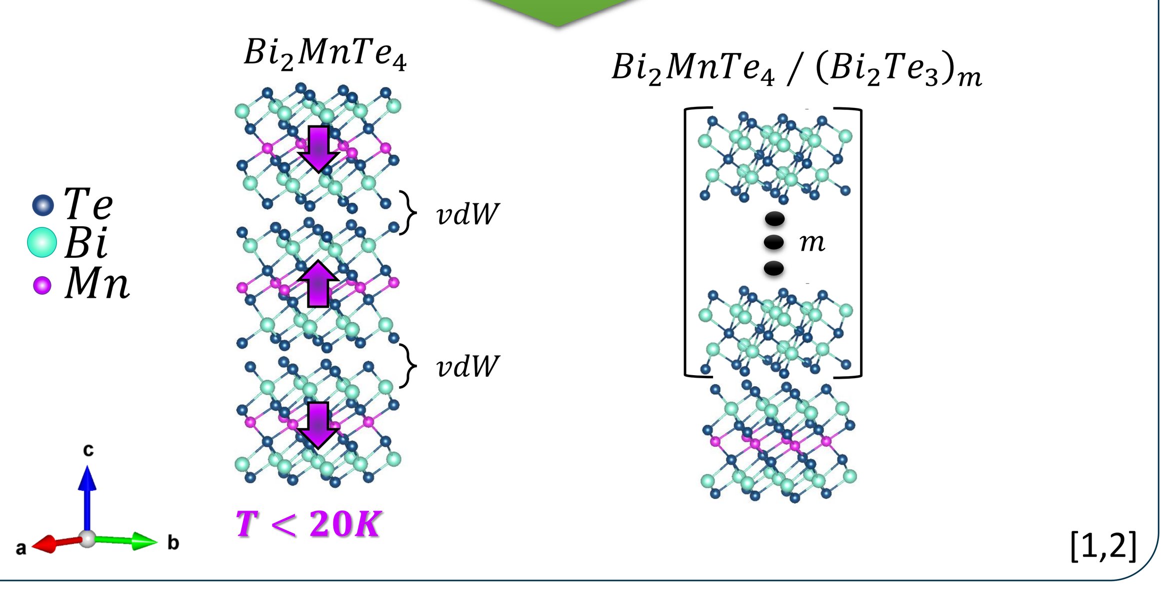
HOW?

Doping nonmagnetic TIs with 3d transition-metal elements → Disorder introduced in the material by doping

Intrinsic magnetic TIs, stoichiometric well-ordered magnetic compounds

Proximity effect in the MI/TI/MI heterostructures → Intrinsic weakness of magnetic proximity effects

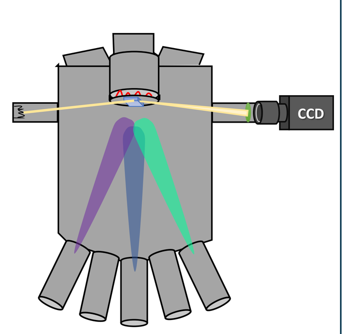
WHAT?



[1,2]

METHODS

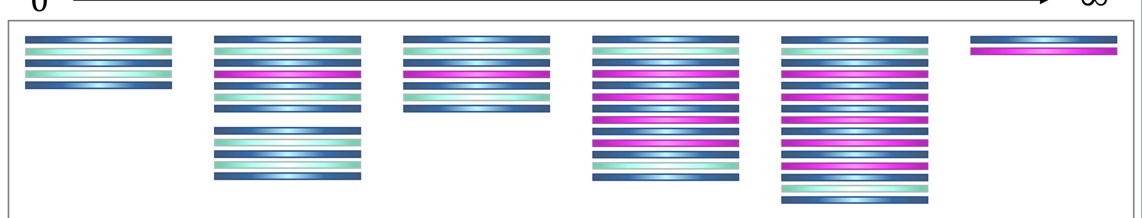
Films of Bi_2MnTe_4 were grown under co-evaporation of Bi, Mn and Te on BaF_2 (111) by molecular beam epitaxy (MBE). For all the samples, the Te:Bi ratio was fixed to 3.01 ± 0.05 and the T_{sub}=380°C.



The films were studied using *in-situ* reflection high energy electron diffraction (RHEED) and *ex-situ* X-ray diffraction (XRD).

The different $Bi_xMn_yTe_z$ phases present in this work are the following:

Φ_{Mn}/Φ_{Bi}: 0 → ∞



Stacking Pattern						
Chemical formula	Bi_2Te_3	Bi_4MnTe_7 [*]	Bi_2MnTe_4	$Bi_2Mn_4Te_7$	$Bi_2Mn_5Te_8$	$MnTe$
# block per unit cell	3	1	3	3	3	1
c	30.510 [3]	23.818 [4]	40.950 [**]	72.251 [***]	82.686 [***]	6.710 [6]
a	4.382 [3]	4.360 [4]	4.334 [2]	4.263 [***]	4.250 [***]	4.148 [6]

* Compact notation of Bi_2MnTe_4/Bi_2Te_3
** Calculated based on XRD measurements performed on recently grown films.
*** Estimated based on the Bi_2MnTe_4, Bi_2Te_3 and MnTe data. $Bi_2Mn_4Te_7$ is reported in [5].

ACKNOWLEDGEMENTS

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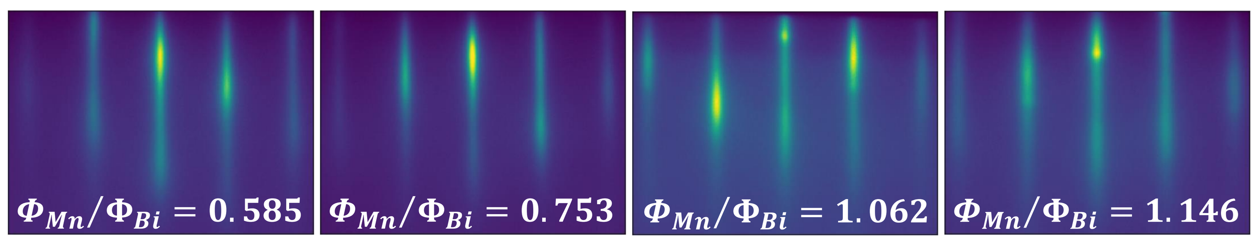
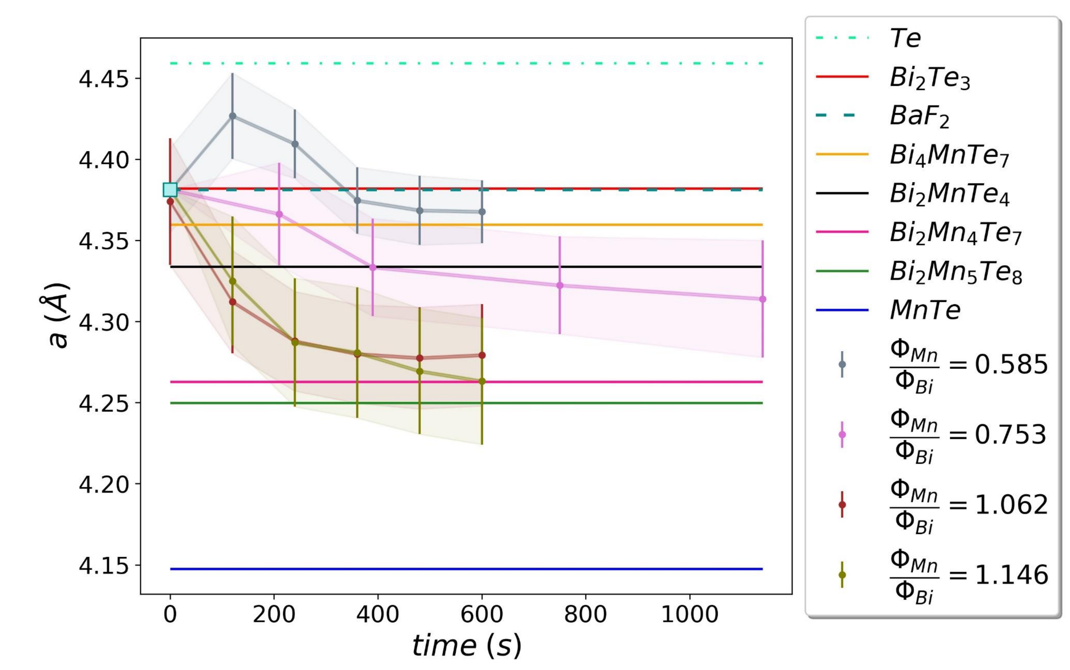
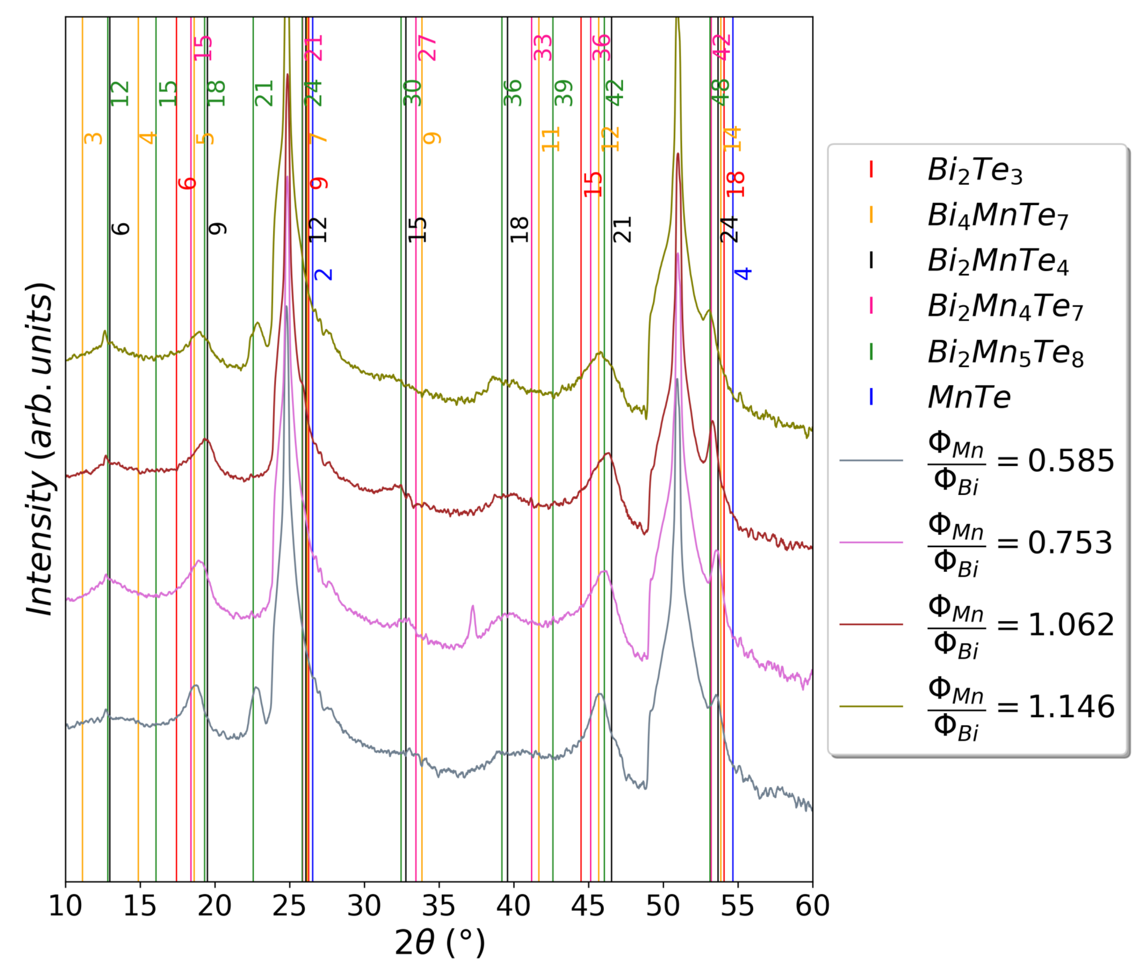
Mn:Bi FLUX RATIOS EFFECT ON THE FILMS CRYSTAL STRUCTURE



RHEED pattern of each film after growth evidencing the good quality of films surface



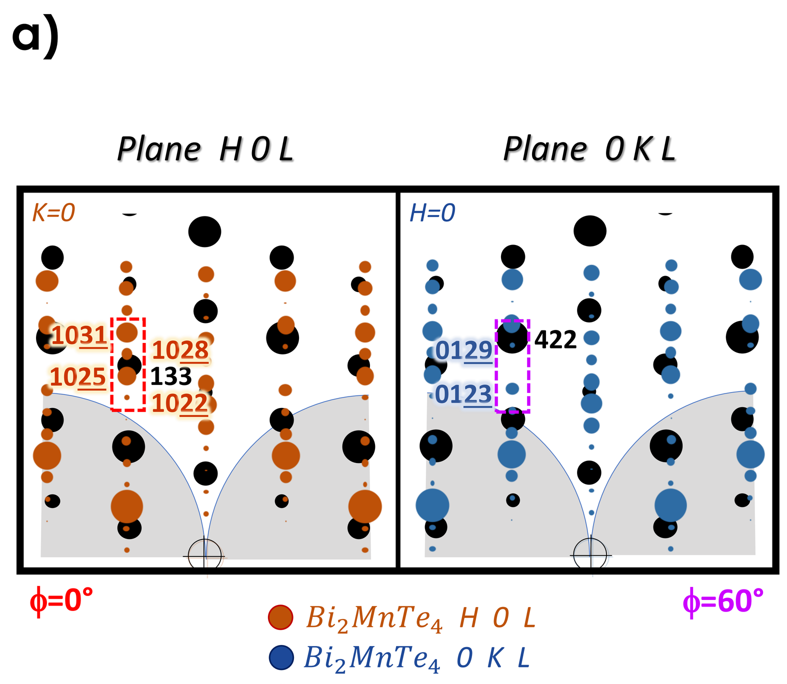
In-plane *a* lattice constant evolution at the beginning of the growth. Since we use a relative measurement method, the starting value represented with a square, which corresponds to the substrate, is fixed all the films. As the ratio Mn:Bi grows, the in-plane lattice constant moves to values that correspond to Mn-richer phases. The bump observed for the Mn:Bi=0.585 results from an excess of Te.

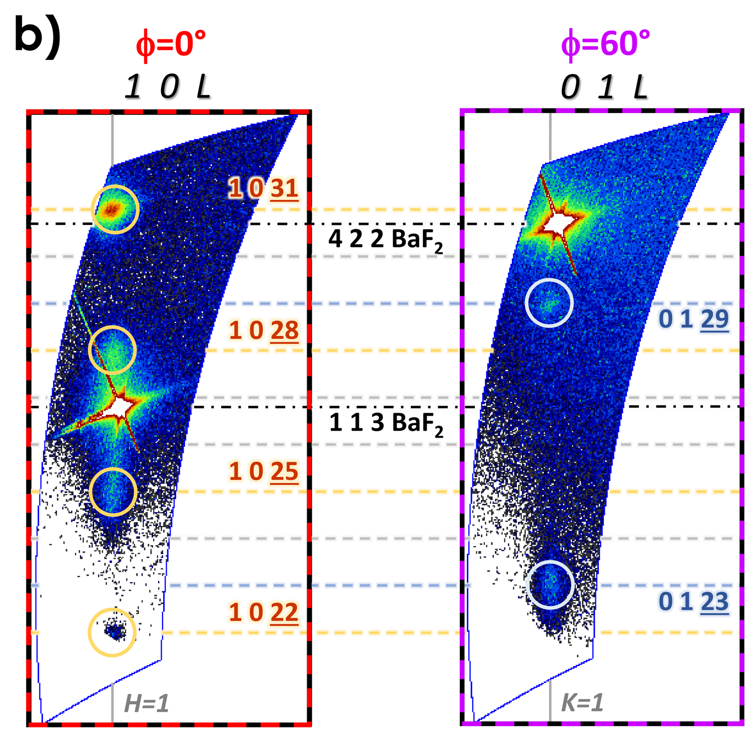


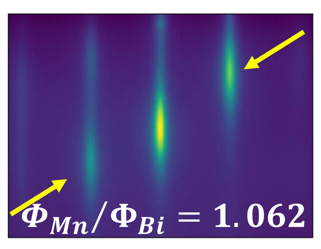
XRD θ-2θ characterization of the films. Peak positions result from the interplay of the different phases. In Mn:Bi=0.585, the main phase is Bi_4MnTe_7. As Mn:Bi rises, Bi_2MnTe_4 becomes in the main phase. However, spurious $Bi_2Mn_4Te_7$ and $Bi_2Mn_5Te_8$ phases emerge parallelly. In Mn:Bi=1.146 a major contribution of $Bi_2Mn_5Te_8$ is evidenced.

TWIN DOMAINS DEFECT STUDY

a) Simulation of the expected reflections for the reciprocal planes H 0 L and 0 K L of Bi_2MnTe_4. The relative intensity is represented by the circle size. **b)** Reciprocal space mapping (RSM) of the sample Mn:Bi=1.062 for indicated reciprocal regions. The absence of an overlapping of the two reciprocal plane patterns evidences the absence of twin domain defects in the films. Even more, a good agreement in the expected relative intensities is observed.



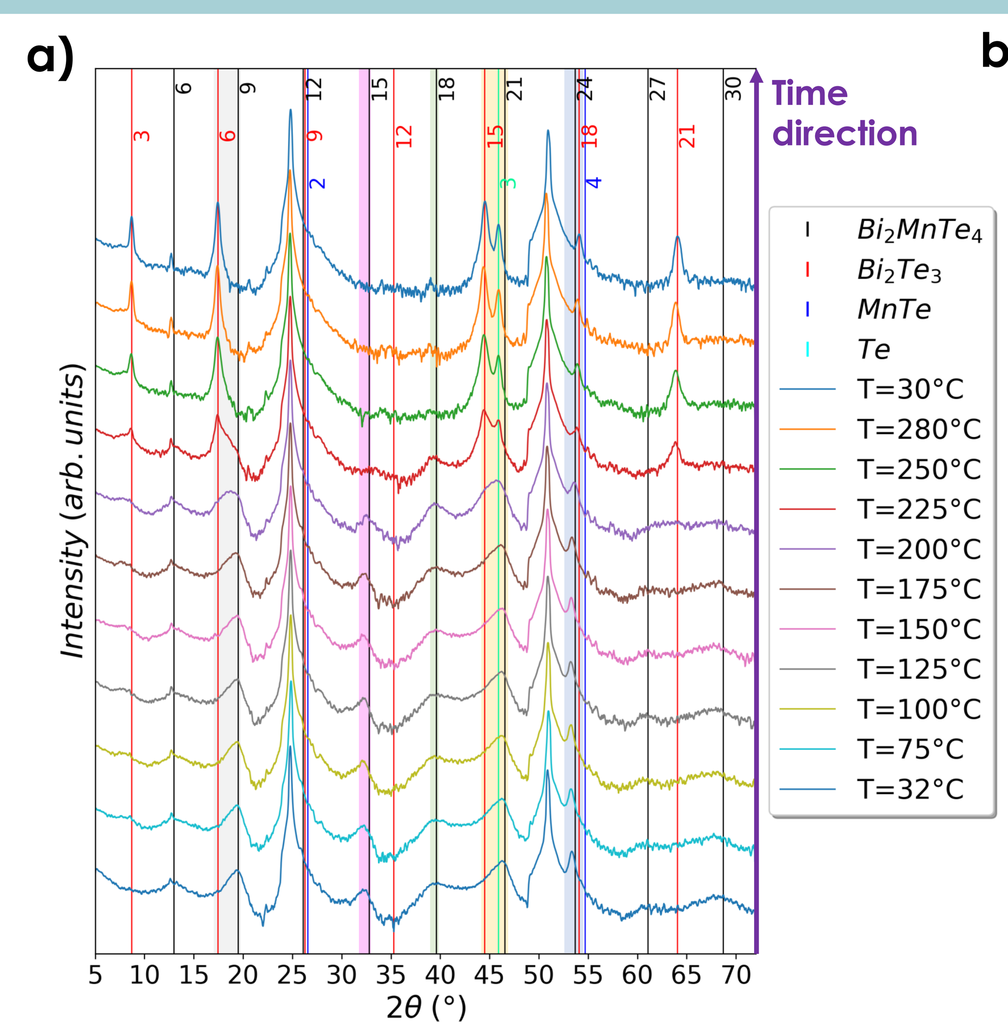


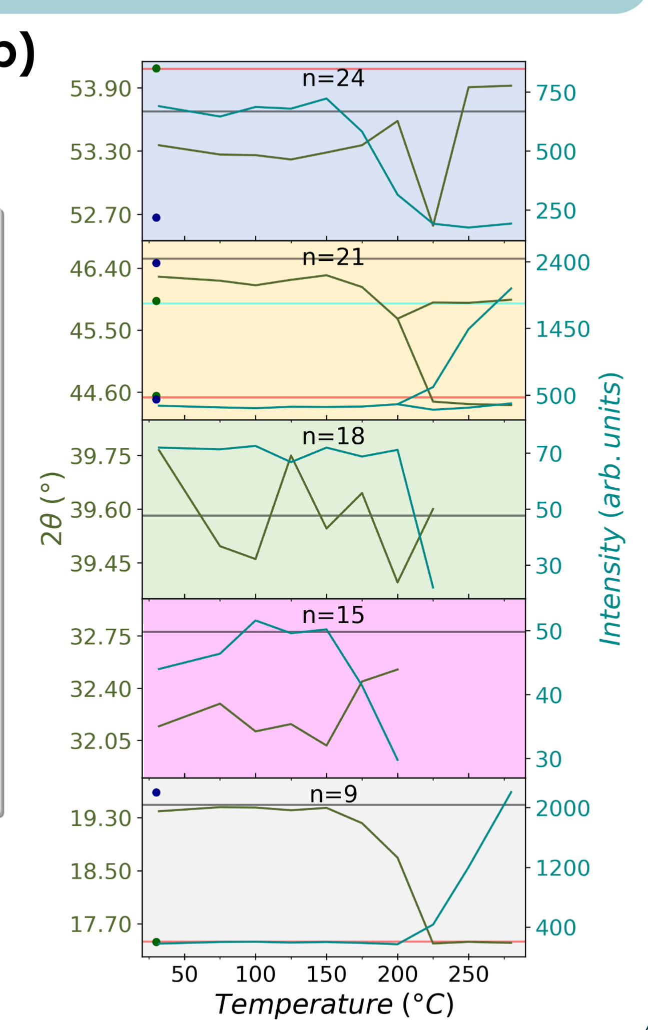


Diagonal modulation in the RHEED pattern also reveals the absence of twin defects [7] .

THERMAL STABILITY OF FILMS STUDY

a) XRD θ-2θ spectrums of the sample Mn:Bi=1.062 as a function of temperature, acquired in rough vacuum conditions (≈10E-1 mbar). **b)** Evolution of the peak's position and peak's intensity for reflections L= 9, 15, 18, 21. The dot represents the peak position after cooling down. Over 150°C, the study shows that the film decomposes in a mixture of Bi_2Te_3 and metallic Te, in which the Mn seems to form an amorphous phase (from additional analysis). Since the film does not recover the initial state after cooling down, the transformation is irreversible. The observations are partially in agreement with previous studies in bulk crystals [2].





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