

Supporting Information for
High Pressure Synthesis and Structure Instability of A-site Ordered
Quadruple Perovskite $\text{LaHg}_3\text{Ti}_4\text{O}_{12+\delta}$

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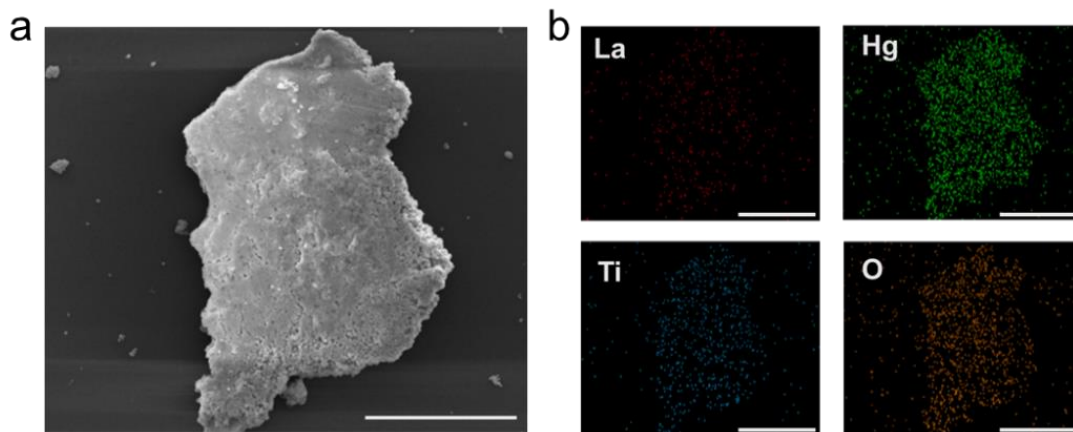


Figure S1. a-b SEM image and EDS mapping of $\text{LgHg}_3\text{Ti}_4\text{O}_{12+\delta}$ (Scale bar: $10\ \mu\text{m}$).

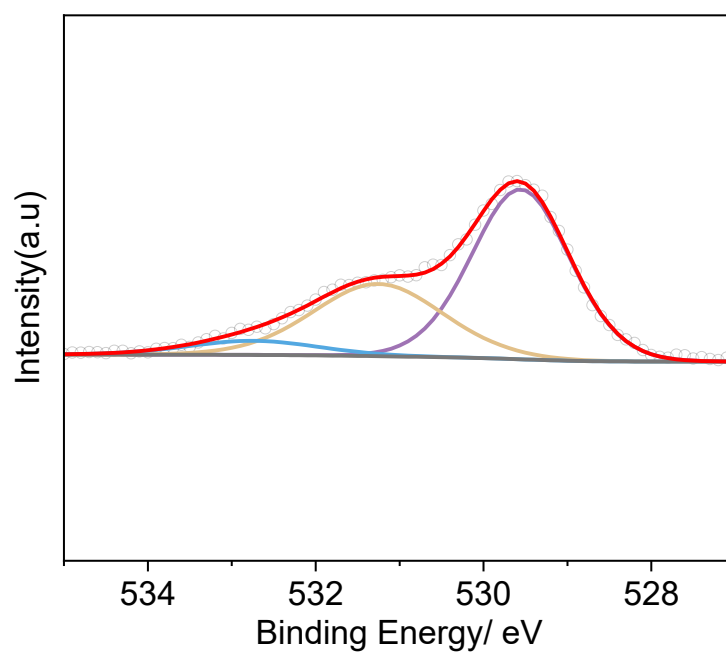


Figure S2. The XPS O $1s$ spectrum for $\text{LaHg}_3\text{Ti}_4\text{O}_{12+\delta}$.

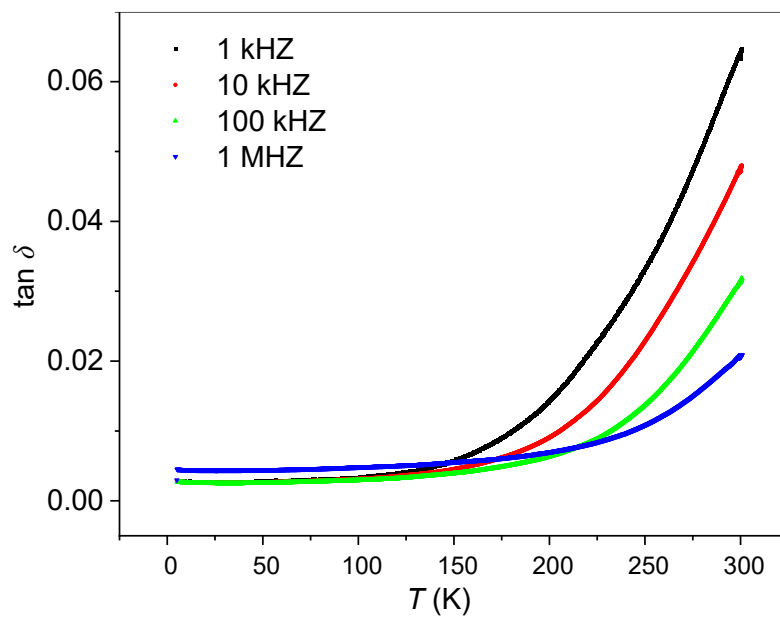


Figure S3. Temperature dependence of dielectric loss from 5 to 300 K.

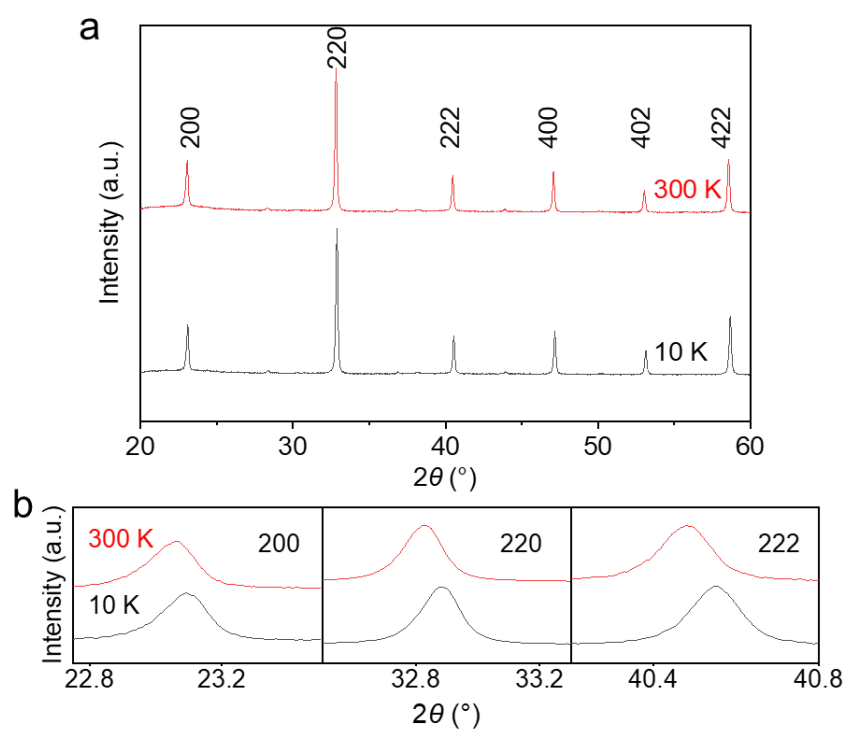


Figure S4. **a** SXR D patterns of LHTO obtained at 300 K and 10 K. **b** some characteristic diffraction peaks collected at 300 K and 10 K

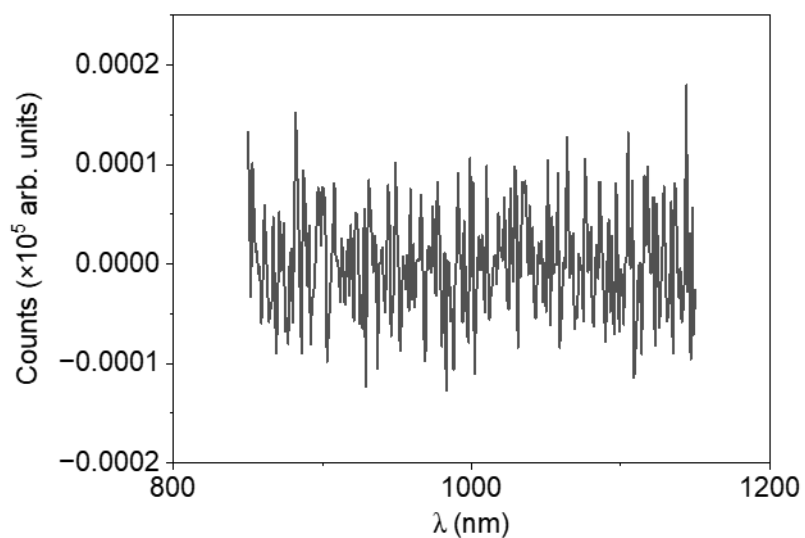


Figure S5. The SHG peak signal measured at room temperature.

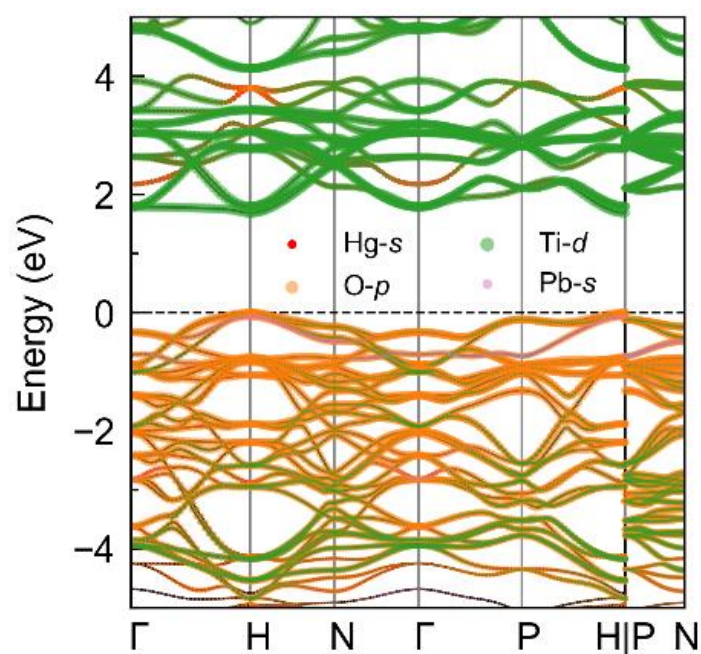


Figure S6. Electronic structure of $\text{PbHg}_3\text{Ti}_4\text{O}_{12}$.

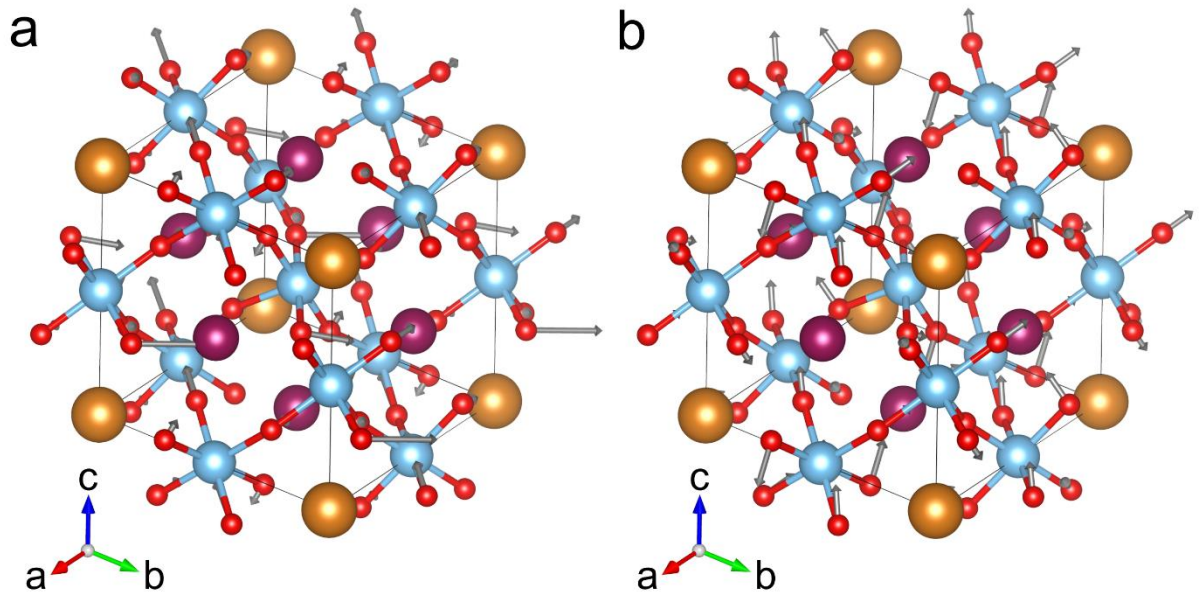


Figure S7. Additional two degenerate soft modes at H point except for that in Figure 4d.

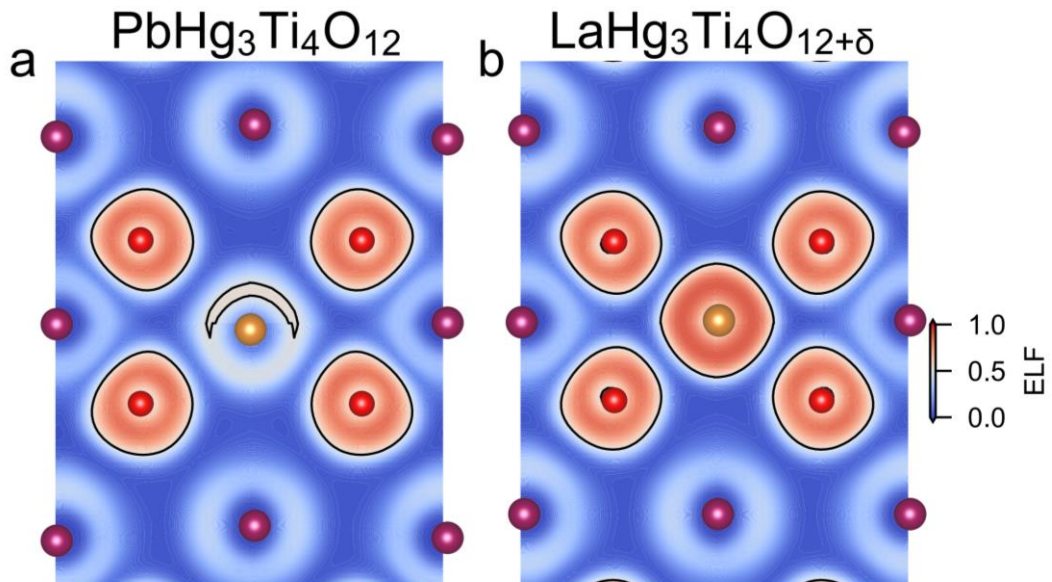


Figure S8. Electron localization function for **a** $\text{PbHg}_3\text{Ti}_4\text{O}_{12}$, and **b** $\text{LaHg}_3\text{Ti}_4\text{O}_{12+\delta}$ at (100) slice. The solid line shows the iso-value $\text{ELF} = 0.5$.