

**SUPPLEMENTARY MATERIALS FOR  
STRUCTURAL PHASE TRANSITIONS IN  
DOUBLE PEROVSKITE CRYSTALS  
STUDIED BY BRILLOUIN LIGHT SCATTERING**

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### S1. DENSITY

From Ref. [10] it follows that for  $\text{Cs}_2\text{AgBiBr}_6$  the volume per functional unit is linear with temperature and equals  $\approx 351 + T/40 \text{ \AA}^3$ . The mass of the functional unit is 1062.094 a.u. ( $= 1.7636 \times 10^{-24} \text{ kg}$ ). As a result, the density is  $\rho_{\text{Br}}(T) \approx 5024.5 - 0.35T \text{ kg/m}^3$ .

Assuming the constant ratio of elementary cell volume of  $\text{Cs}_2\text{AgBiCl}_6$  and  $\text{Cs}_2\text{AgBiBr}_6$  as a function of temperature, we take the values from XRD measurements and using the mass of functional unit 795.37 a.u. ( $1.3207 \cdot 10^{-24} \text{ kg}$ ), one obtains for the density  $\rho_{\text{Cl}}(T) \approx 4303.8 - 0.30T \text{ kg/m}^3$ .

### S2. DETERMINATION OF CRYSTALL DIRECTIONS

Powder X-ray diffraction measurements show that  $\text{Cs}_2\text{AgBiBr}_6$  and  $\text{Cs}_2\text{AgBiCl}_6$  samples at room temperature are in a cubic phase. For  $\text{Cs}_2\text{AgBiBr}_6$ , it is known from literature and confirmed by high-resolution transmission electron microscopy that the crystals grow along  $\langle 111 \rangle$  crystallographic direction [21]. The other possibility to evaluate the growth direction is to examine the shape of the crystal. Both  $\text{Cs}_2\text{AgBiBr}_6$  and  $\text{Cs}_2\text{AgBiCl}_6$  perovskites have the same shape: a doubly-truncated regular octahedron, with truncations performed by planes parallel to a pair of opposing triangular faces. The crystals were polished along  $\langle 100 \rangle$  and  $\langle 110 \rangle$  directions Figure S1.

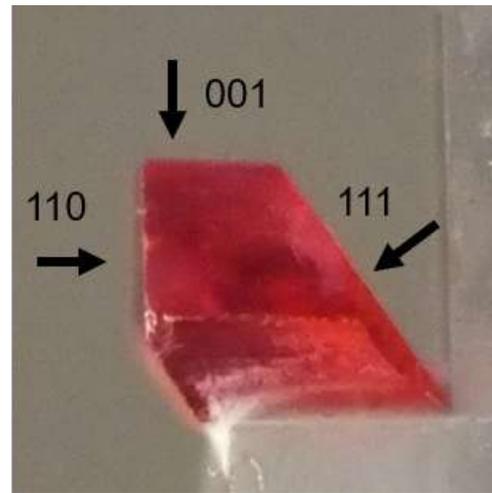


Figure S1. Photo of a polished sample  $\text{Cs}_2\text{AgBiBr}_6$  with  $\langle 001 \rangle$ ,  $\langle 110 \rangle$  and  $\langle 111 \rangle$  crystallographic directions. The pointed arrows represent the normal vectors to the surface and lie within the plane of the figure.

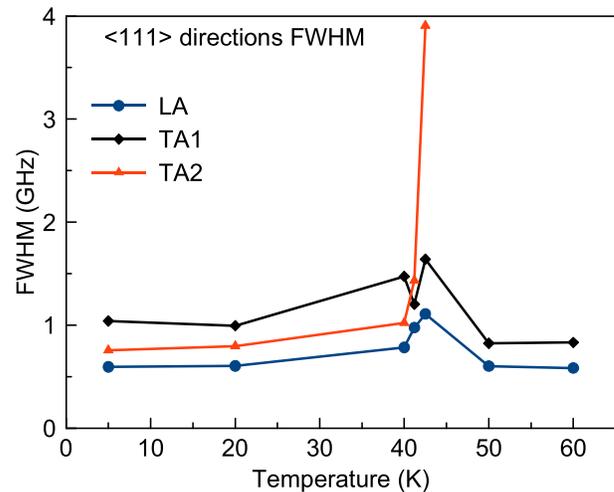


Figure S2. Full width at half maximum of Brillouin peaks corresponding to scattering on TA and LA phonons as a function of temperature in  $\text{Cs}_2\text{AgBiCl}_6$  measured along  $\langle 111 \rangle$  crystallographic direction at room temperature.