

Supplementary Figures

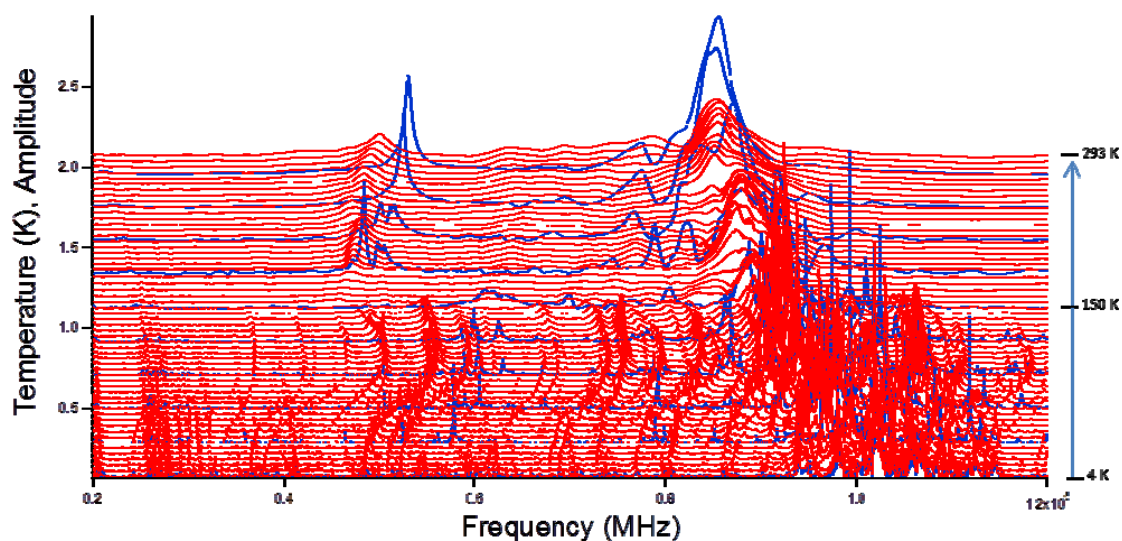


Fig. S1 Primary RUS spectra from a single crystal of $\text{CH}_3\text{NH}_3\text{PbI}_3$. Each spectrum has been offset up the y-axis in proportion to the temperature at which it was collected. Blue spectra collected during cooling, red spectra collected during heating.

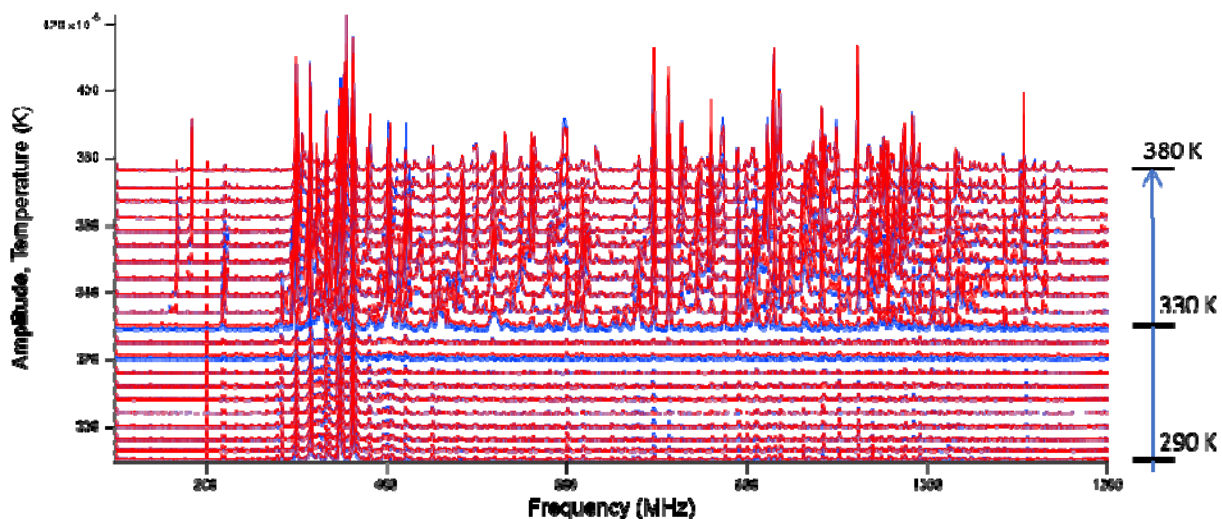


Fig. S2 - Primary RUS spectra from a single crystal of $\text{CH}_3\text{NH}_3\text{PbI}_3$ from 290 – 380 K. Each spectrum has been offset up the y-axis in proportion to the temperature at which it was collected. Blue spectra collected during cooling, red spectra collected during heating. Note that most of the peaks which show little or no change in their position in response to changing temperature are from the alumina buffer rods and not the sample. Resonances from the sample disappear abruptly (strong attenuation) below the cubic – tetragonal transition at ~ 330 K.

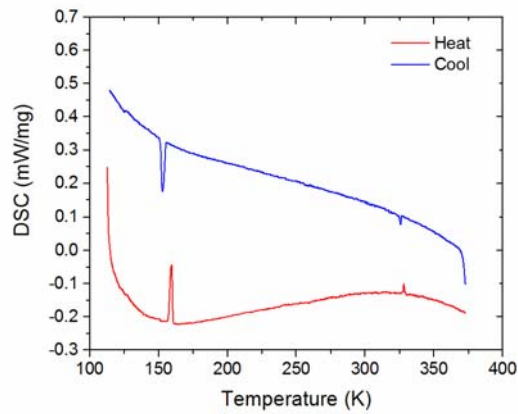


Fig. S3: Differential Scanning Calorimetry (DSC) data for $\text{CH}_3\text{NH}_3\text{PbI}_3$.

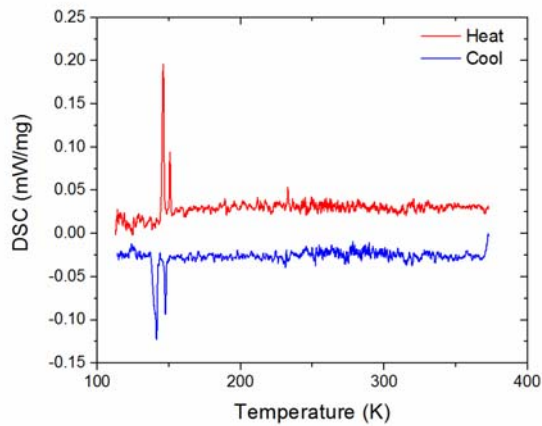


Fig. S4: Differential Scanning Calorimetry data for $\text{CH}_3\text{NH}_3\text{PbBr}_3$.

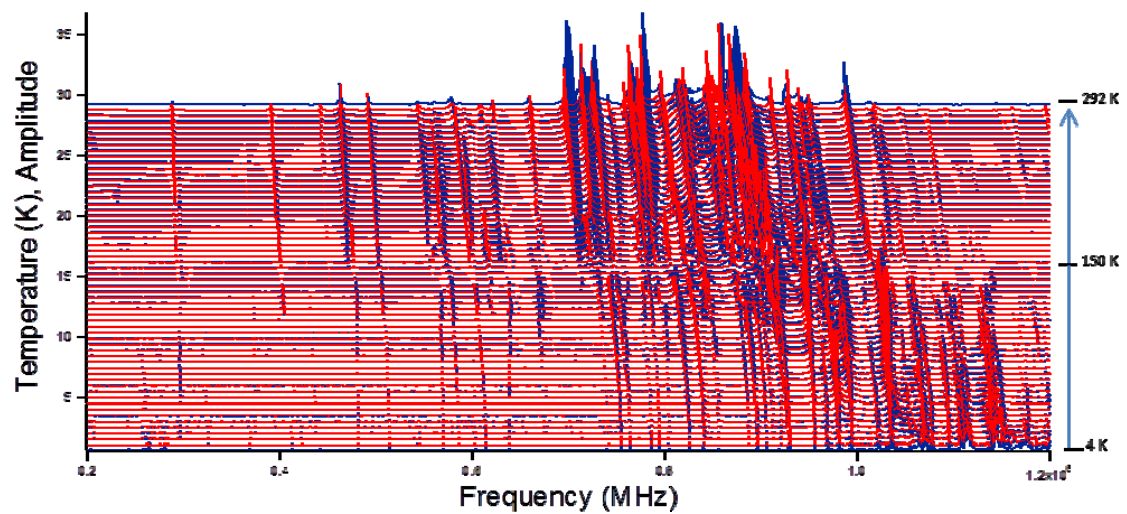


Fig. S5. Primary RUS spectra from a single crystal of $\text{CH}_3\text{NH}_3\text{PbCl}_3$. Each spectrum has been offset up the y-axis in proportion to the temperature at which it was collected. Blue spectra collected during cooling, red spectra collected during heating.

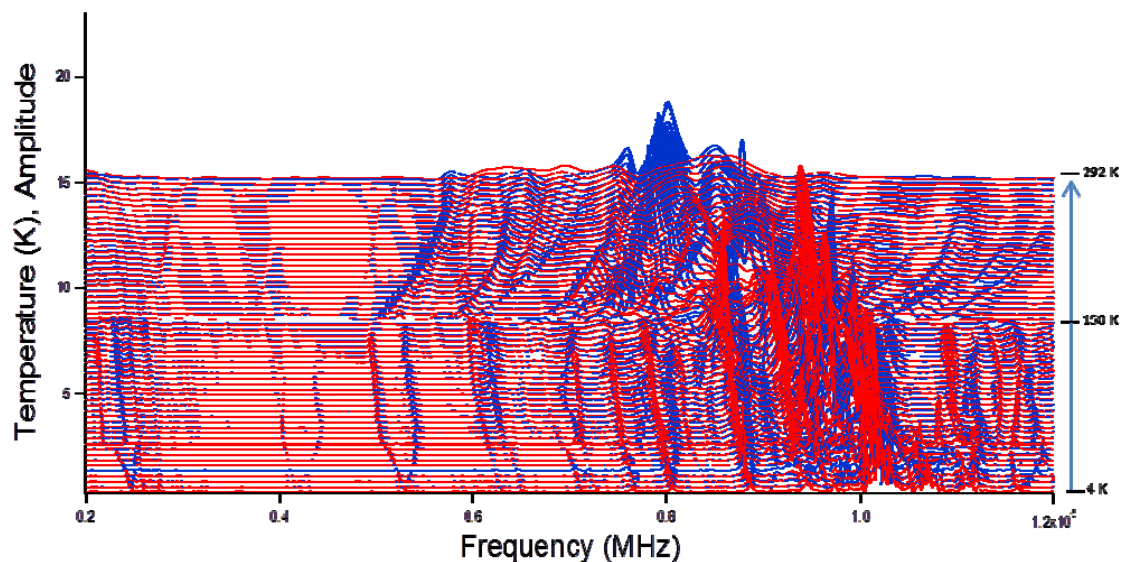


Fig. S6 – Primary RUS spectra from a single crystal of $\text{CD}_3\text{ND}_3\text{PbI}_3$. Each spectrum has been offset up the y-axis in proportion to the temperature at which it was collected. Blue spectra collected during cooling, red spectra collected during heating.

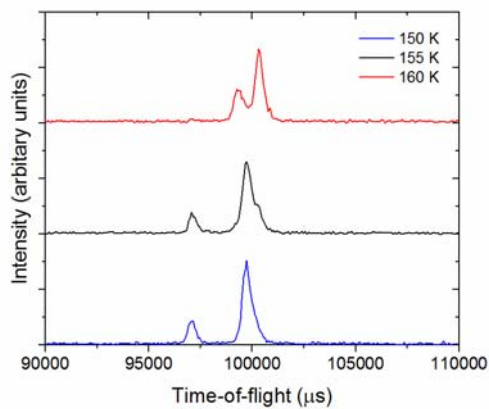


Fig. S7: Powder neutron diffraction data in the region around the orthorhombic –tetragonal phase transition showing phase coexistence.

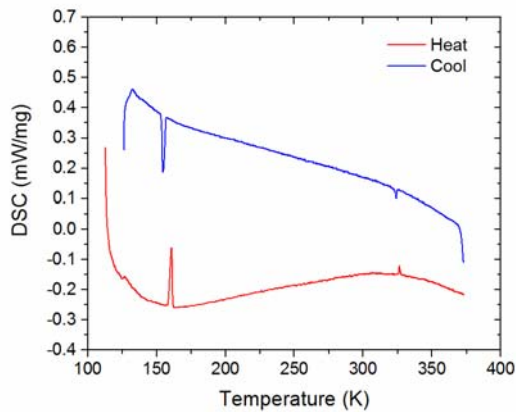


Fig. S8: Differential Scanning Calorimetry (DSC) data for $\text{CD}_3\text{ND}_3\text{PbI}_3$.

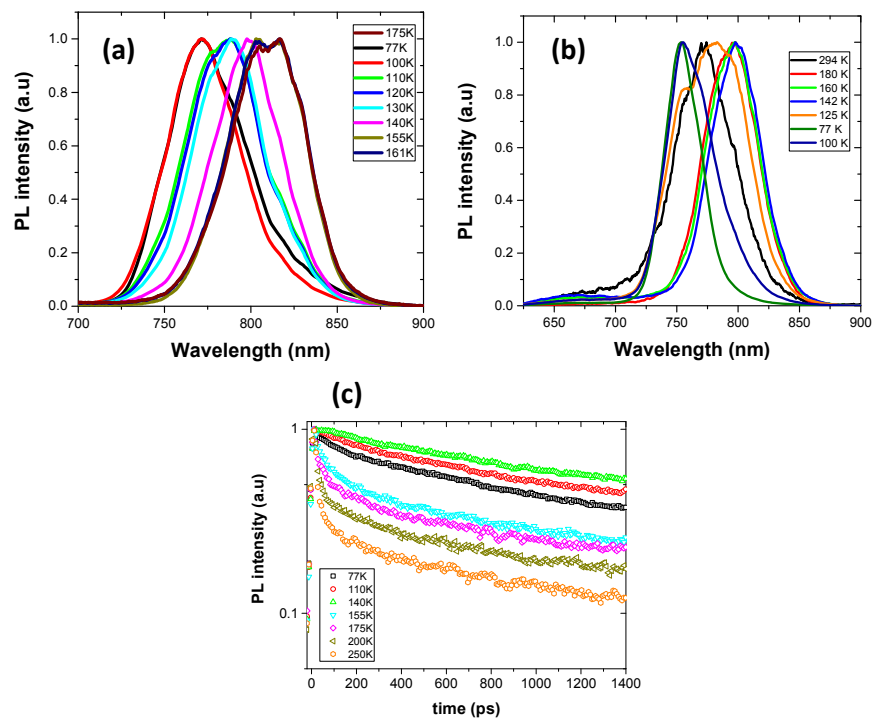


Fig. S9 – Photoluminescence Spectra for (a) $\text{CH}_3\text{NH}_3\text{PbI}_3$ and (b) $\text{CD}_3\text{ND}_3\text{PbI}_3$ at various temperatures. (c) Time resolved photoluminescence of $\text{CH}_3\text{NH}_3\text{PbI}_3$ – note that the PL lifetime suddenly spikes around 140 K