**Supplementary Information**

**Observation of roton-like dispersion relations in acoustic metamaterials**

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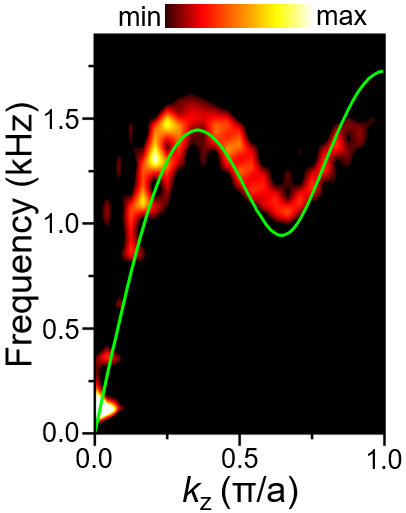
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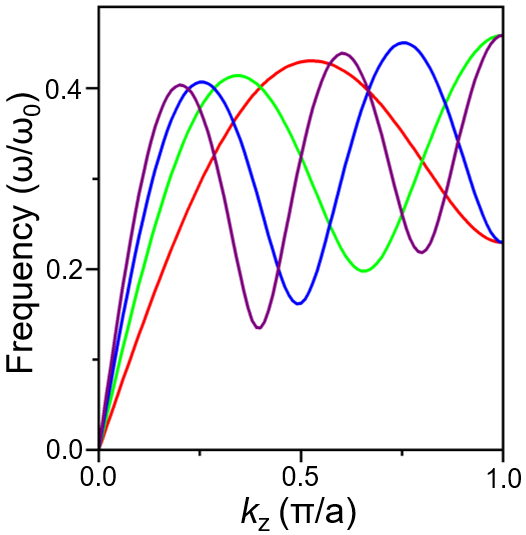
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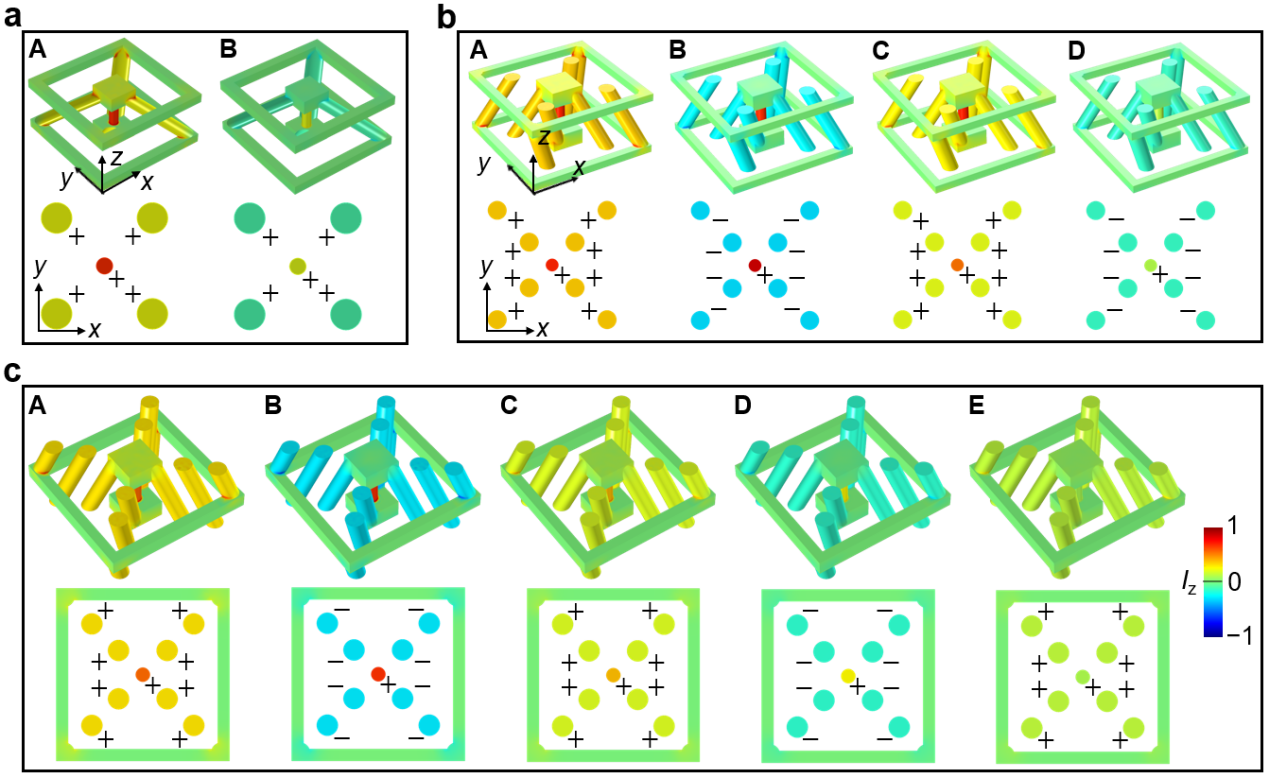
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**Supplementary Figure S1 The fitted curve (green line) of the measured dispersion (red colour) with third-nearest-neighbour interactions using the 1D toy model.**



**Supplementary Figure S2 Calculated roton-like dispersion relations for four 1D toy models with beyond-nearest-neighbour interactions.** The dispersion relations for four 1D toy models with *N* = 2 (red curves), 3 (green curves), 4 (blue curves), 5 (purple curves), respectively. The parameters are *KN*/*K*1 = 3 with *N* = 2, 3, 4, 5 and , respectively.



**Supplementary Figure** **S3 The mean energy fluxes of different eigenmodes at the same frequency of 1.35 kHz for (a) *N* = 2, (b) N = 4 and (c) N = 5, respectively.**