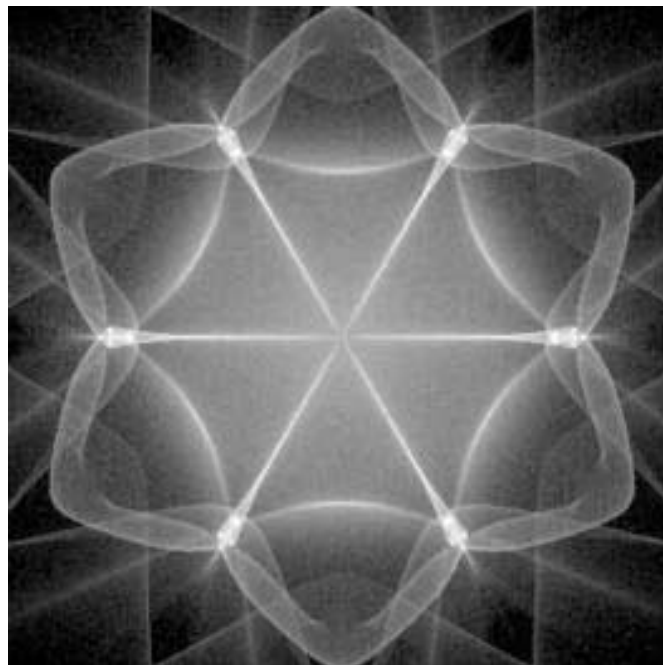


# Images of phonons transmitted across twist-bonded (111)-oriented cubic crystals : Symmetry doubling in the ballistic intensity

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Symmetry in the images of the ballistic phonons transmitted through twist-bonded crystals is studied. Interestingly, the predicted focusing patterns are nontrivial, that is, they are not simply the superposition of the images in both crystals weighted by the relative thickness of the layers. In addition, under certain conditions, an extra symmetry should be observed in the focusing patterns. This is the case for the phonons, for example, transmitted through identical (111)-oriented cubic wafers twist bonded at a  $60^\circ$  angle. The symmetry doubling, i.e., a six-fold symmetry instead of a three-fold symmetry, should be seen. This can be confirmed by geometrical consideration. However, it is not obvious if the intensity distribution has also the same symmetry. We find that this symmetry in the focused ballistic intensity is indeed realized if the occupation number of phonons injected is independent of the phonon polarizations and wave-vector directions. We illustrate the results for the focusing of phonons in twist bonded (111) silicon crystals.



Monte Carlo-calculated images of phonons transmitted through twist-bonded (111) silicon crystals (of the same thickness) with a twist angle of  $60^\circ$ .