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Experimental and theoretical investigations of focusing of ultrasonic waves by two-dimensional flat phononic crystals

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We compare experimental and theoretical results demonstrating focusing of sound fields emitted by subwavelength sources using two-dimensional flat phononic crystals. Our phononic crystals are made of stainless steel rods assembled in a triangular crystal lattice and immersed in a liquid. Focusing is achieved due to negative refraction of ultrasonic waves propagating through the crystal, which is realized at the frequencies corresponding to the 2nd band, where the group velocity and wave vector are antiparallel. High quality images are obtained experimentally with a methanol-filled phononic crystal surrounded by water, in which the source and detecting transducers are located. Excellent resolution approaching the diffraction limit is achieved for the frequency at which the equifrequency contours inside the crystal match those in water. Our experimental results are compared with theoretical predictions by the Finite Difference Time Domain (FDTD) method. Good agreement is observed for the width of the focal spot in the direction parallel to the crystal surface, while along the perpendicular direction, we find experimentally that the focal spot is narrower and closer to the crystal surface than in the theoretical predictions.