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Acoustic Bloch oscillations, Wannier-Stark ladders and negative refraction in ultra- and hypersonic superlattices

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A new and very efficient ultrasonic superlattice is realized for the study of such fundamental effects of quantum transport in a perturbed periodic potential as acoustic Bloch oscillations, Wannier-Stark ladders and resonant Landau-Zener tunneling. The acoustic equivalent of the Wannier-Stark ladders is employed in a set of water cavities, with a gradient of the thicknesses, in a simple water-solid multilayer system. Bloch oscillations in different acoustic minibands are observed as time-resolved oscillations of the transmisssion of ultasonic pulses with corresponding spectral positions and widths. Acoustic Bloch oscillations with different temporal periods for the pulses centered in two neighboring acoustic minibands are observed. Experimental observations are in very good agreement with the transfer-matrix simulations [1]. The propagation of acoustic pulse in an even acoustic miniband in orthogonal or oblique with respect to the superlattice axis direction will result in negative refraction and Bloch oscillations of acoustic pulse with "negative effective mass", which can be visualized by mapping out of acoustic pressure field. Hypersonic phononic structures, which can be fabricated with the use of interference lithography, render possible the observation of all the abovementioned acoustic phenomena in the hypersound frequency range.
1. H. Sanchis-Alepuz, Yu. A. Kosevich, and J. Sanchez-Dehesa, 2007, Phys. Rev. Lett. v. 98, 134301.