An Acoustic Metasurface: From Transmitted Waves Manipulation to Surface Modes Excitation

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An acoustic metasurface is constructed from a rigid thin plate by introducing periodically repeated supercells on the plate, where each supercell contains multiple cut-through slits that are filled with materials possessing different refractive indices but the same impedance as the host medium. When the wavelength is smaller than the periodicity of the supercell, an arbitrarily desired direction of the transmitted beam with nearly unity transmission can be obtained by engineering the phase discontinuities along the transverse direction. On the other hand, when the wavelength is larger than the periodicity, even though the metasurface is impedance-matched to the host medium, most of the incident energy is reflected back and the remaining portion is converted into surface bound mode. Both the transmitted beam control and surface mode excitation can be interpreted by a unified analytic model based on the mode-coupling theory. A simple method to realize the acoustic metasurface by using existing natural materials is provided as an example. Our designs not only supply the functionalities of the reflective-type acoustic meatsurfaces, but also exhibit unprecedented flexibility and efficiency in various possibilities of wave manipulation that may have potential implications in fields like wave energy refracting, collimation, focusing and enhanced absorption.