Metadiffusers, deep subwavelength acoustic diffusers

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Sound diffusers are locally-reacting reflecting surfaces with spatially dependent reflection coefficient designed to produce uniform scattering, i.e., the reflected waves by these surfaces are dispersed in many different directions. Therefore, diffusers present a uniform far field magnitude, i.e. a uniform magnitude Fourier transform of its spatially dependent reflection coefficient distribution. The generation of spatially dependent reflecting surfaces is commonly achieved by using phase grating diffusers, also known as Schroeder's diffusers, that are rigid-backed slotted panels where each slit acts as a quarter wavelength resonator. However, Schroeder diffusers are limited by their depths, which becomes large at low design frequencies. This results in thick and heavy panels, limiting the use of phase grating diffusers for low-frequencies where the wavelength of sound in air is of the order of several meters. Here, we present the concept of metadiffusers which are deep-subwavelength thickness diffusers based on acoustic metamaterials to reduce the thickness of Schroeder diffusers. The system works as follows: first, we consider a rigid panel of finite length with a set of N slits. Second, we modify the dispersion relations inside each slit by loading one of their walls with a set of HRs. The sound propagation becomes strongly dispersive in each slit and the resulting sound speed is drastically reduced. Therefore, each slit behaves as a deep-subwavelength resonator. As a consequence, the effective depth of the slits can be strongly reduced. By tuning the geometry of the HRs and the thickness of the slits, the phase of the reflection coefficients can be tailored to those of usual diffusers but with deep subwavelength structures.