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Optimal Bi-State Acoustic Metamaterial for Broadband Sound Absorption and Diffusion: A Real-Estate Dilemma

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The advent of metamaterials has given a new breath to acoustic treatment design due to their ability to target much lower frequencies within deep-subwavelength dimensions. However, many practical applications may require a multi-functional structure instead of a static one with a single purpose and thus overturn geometry-specific performance. Such hybrid acoustic treatments have been an active field of research for the past decades, in which a trade-off between different acoustical mechanisms has to be struck, the major issue being the inversely decreasing returns for each acoustical mechanism, i.e., the more of one the less of the other. The aim of the present work is to build over previous metamaterial strategies and design a dynamic bi-state passive acoustic metamaterial that can change its acoustic properties within the same structural volume, going from highly absorbent ($\alpha \sim 0.85$) to diffusive ($\delta \sim 0.65$) over more than one octave for each acoustic phenomenon, i.e., 400-1100 Hz and 1000-2500 Hz for absorption and diffusion, respectively, with an overall thickness $L = 12$ cm two times thinner than traditional acoustic treatments. Such design can help enhance the acoustics of rooms but it can also be introduced to critical environments with limited space, such as aerospace.