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Rainbow-trapping absorbers for transmission problems: Broadband and perfect sound absorbing panels

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Broadband and perfect sound absorption by subwavelength panels for transmission problems is reported. The asymmetric panels are composed of a periodic array of open waveguides loaded by Helmholtz resonators (HRs) with slightly different dimensions along the structure depth. In each waveguide, the deepest resonator generates a low cut-off frequency, reducing drastically the transmission. The geometry of the preceding HR is designed to possess a slightly higher resonance frequency and is tuned to match the structure impedance with the surrounding one, thanks to the critical coupling condition. Therefore, reflection vanishes and the structure becomes critically coupled to the incident wave, resulting in perfect sound absorption. This process is repeated by adding HRs, whose resonance frequency is slightly higher than the preceding one, to each waveguide. The last added HR fixes the high cut-off frequency of the perfect absorption band in such a way that slow sound condition is achieved within each open waveguide over a broadband frequency range. We experimentally, theoretically and numerically report perfect sound absorption for two panels: (1) at 300 Hz for a transparent panel of total thickness 2.8 cm, i.e., 40 times smaller than the wavelength, (2) from 350 to 1000 Hz for a transparent panel composed of 9 resonators with a total thickness of 12 cm, i.e., 10 times smaller than the wavelength and covering almost two octaves.