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Transmission gaps and Fano resonances in a simple acoustic waveguide: Analytical model

El Houssaine El Boudouti[a], Tarik Mrabti[a], Hosni Al-Wahsh[b], Bahram Djafari-Rouhani[c], Abdellatif Akjouj[c] and Leonard Dobrzynski[c]

[a]Faculté des Sciences, Département de Physique, Université Mohamed I, 60000 Oujda, Morocco
[b]Faculty of Engineering, Benha University, 11241 Cairo, Egypt
[c]IEMN, UMR CNRS 8520, avenue Poincaré, BP 60069, 59652 Villeneuve d'Ascq, France

A simple acoustic device consisting of two dangling side resonators grafted at two sites on a slender tube is designed to obtain possibly transmission stop bands where the propagation of longitudinal acoustic waves is forbidden. Contrary to all known systems of this kind, a spectral transmission gap of nonzero width occurs here even with this simple structure. This is obtained by combining appropriately the zeros of transmission of the side resonators. Sharp resonant states inside the gaps can be achieved without introducing any defects in the structure. This results from an internal resonance of the structure when such a resonance is situated in the vicinity of a zero of transmission or placed between two zeros of transmission, the so-called Fano resonances. A general analytical expression for the transmission coefficient is given for these systems within the framework of the Green's function method. The amplitude and the phase time of the transmission are discussed as a function of frequency and it is shown that the width of the stop bands is very sensitive to the number of the side resonators. These results should have important consequences for the suppression of low-frequency noise and for designing filters.