Design of elastic wave metasurfaces using topology optimization

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Abstract

Recently, the concept of metasurface has attracted a great attention due to its remarkable manipulation capabilities of wavefront. Although extensively exploited in the electromagnetic and acoustic fields, the design of its elastic wave counterparts remains challenging due to the co-existing different polarized modes. In addition, for problems aiming at manipulating transmitted waves, high transmission is always desired but difficult to achieve [1].

In this talk, we present a computational approach for systematic design of elastic-wave metasurface with multiple objectives. A unified topology optimization formulation is constructed for the design of a series of unit cells with specified phase shifts covering the range of $[0,2\pi]$, while maintaining a high energy transmission. These unit cells can then be arranged according to a certain phase profile to realize the desired wave front.

The proposed method has been applied for the design of two novel types of elastic wave metasurfaces. In the first design, simultaneous control of longitudinal and shear waves is implemented; while in the second one, a metasurface is designed to realize different but controllable manipulation for waves with different frequencies. The designs have been validated using full numerical simulations based on the finite element method. Theoretical study based Bloch mode analysis has also been conducted. It has been found that the high transmission achieved in these designs is due to multiple wave interference, which has the effect of impedance compensation if the unit cell is properly designed.

Keywords: elastic wave metasurface; topology optimization

References

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