Temperature Gradients Controlled Broadband Acoustic Omnidirectional Absorber

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Abstract

Previous research into acoustic omnidirectional absorber (AOA) has shown the feasibility of forming acoustic black hole to guide the incident wave into the central absorptive cavity[1]. However, major restrictions to practical applications exist due to complexity of designing metamaterials and unchangeable working states[2-5]. As we all know, temperature will affect the sound velocity, which equivalently changes the refractive index of the medium. It is naturally to inspire us to utilize temperature gradients to obtain the desired refractive index to control the sound propagation[6, 7].

Here, we propose two cylindrical, two-dimensional AOA schemes based on temperature gradients for airborne applications. One scheme with accurately designed temperature gradients has better absorption performance which can almost completely absorb the incident wave, while the other one with simplified configuration has low complexity which is much more easily to realize (Figure 1&3).

Both pressure acoustics (acpr) interface and general heat transfer (htgh) interface are used. The acoustic field and thermal field are coupled by COMSOL Multiphysics®. Geometric acoustics is used to obtain the refractive index distributions with different radii, which is then utilized to deduce the desired temperature gradients (Figure 2). Both schemes are temperature-tuned with broad working bandwidth (Figure 3). We expect that our study will motivate further research work or potential application in fields such as noise control, acoustic illusion or acoustic mirage[8, 9].

Reference

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Figures used in the abstract

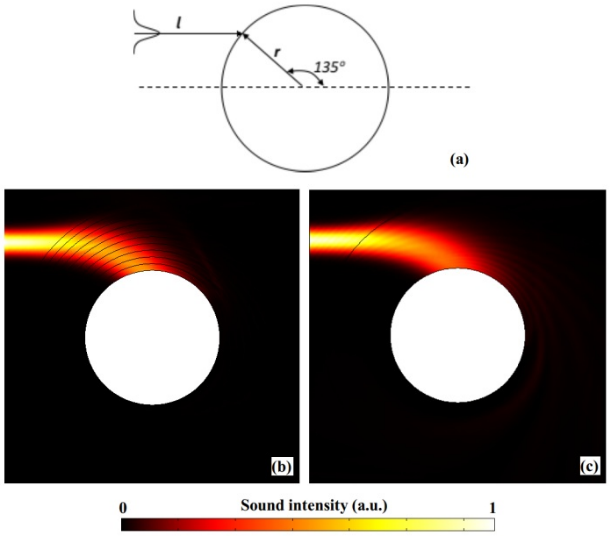

Figure 1: (a) The schematic diagram of the incident angle. (b),(c) Respective intensity fields of the accurately designed and simplified TGAOA schemes with an incident 13000Hz Gaussian wave.

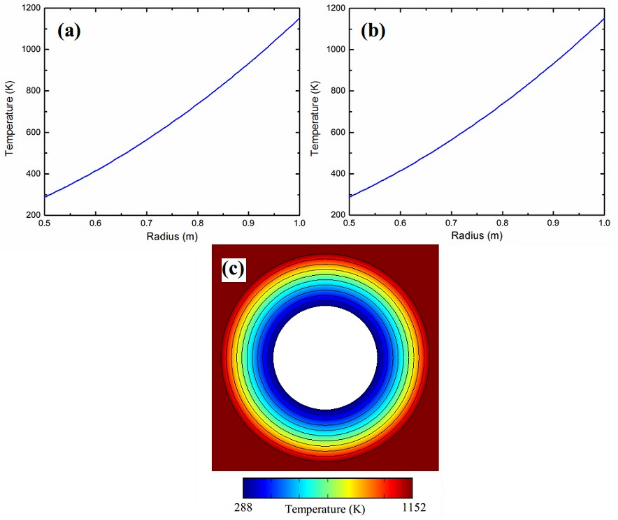

Figure 2: (a)The theoretical temperature distribution corresponding to the radius. (b) The temperature distribution corresponding to the radius obtained using finite element method. (c) The temperature field of the accurately designed scheme consists of ten layers with heat sinks.

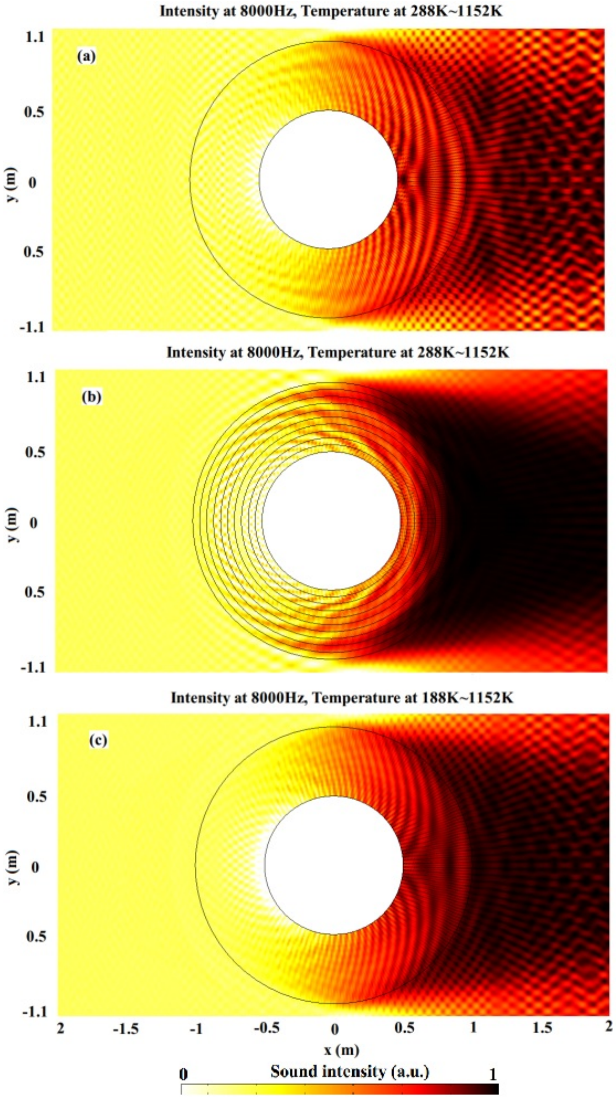

Figure 3: (a),(b) Respective intensity fields of the simplified and accurately designed TGAOA schemes with an incident 8000Hz plane wave. The temperature at inner radius is 288K; the one at outer radius is 1152K. (c) Intensity field of the simplified TGAOA schemes with an incident 8000Hz plane wave. The temperature at inner radius is 188K; the one at outer radius is 1152K.