ICCES, 2024, vol.30, no.4
DOI: 10.32604/icces.2024.012376

PROCEEDINGS

Wave and Particle Manipulation by Acoustic and Electromagnetic Metamaterials

Xiaobing Cai[1]

[1]State Key Laboratory for Strength and Vibration of Mechanical Structures, School of Aerospace Engineering, Xi'an Jiaotong University, No.28 Xianning West Road, Xi'an, 710049, China

*Corresponding Author: Xiaobing Cai. Email: caixiaobing@xjtu.edu.cn

ABSTRACT

Acoustic and Electromagnetic Metamaterials/Metasurface have demonstrated various fascinating functionalities in wave manipulation. However, further employment of the manipulated wave for controlling the movement of discrete particle matter is not so widely investigated. Particle matter, also known as granular matter, granular material etc, is the most common form of matter in nature, and so the effective control of granular matter is closely related to engineering and daily life. The use of sound waves and electromagnetic waves to manipulate the granular matter has been widely used in printing, environmental protection, pharmaceuticals and many other fields. However, in many traditional technical solutions, the surrounding medium in which the particles are located or dispersed in usually possesses a positive Young's modulus or a positive dielectric constant, thus resulting in very small acoustic or electric field gradient forces on the particles. This work illustrates that in the vicinity of a metasurface with negative modulus or negative dielectric constant, the gradient force experienced by particles could be increased by two orders of magnitude. This provides an effective and promising avenue for the use of metasurfaces for high-efficiency particle movement manipulation. Based on this principle, this work provided specifical methods for size-classifying and aggregating particles such as cells in microfluidics, and for preventing dust particles from depositing on the surface of solar panels during lunar and Mars exploration. Moreover, this work also takes advantage of the particle size/pore size stratification phenomenon that occurs when granular matter naturally accumulating under the effect of gravity, and in turn designs a device that naturally realizes the carpet transparency of electromagnetic waves through granular matter. Using bubbles as inverse granular matter, a solution was designed to increase the transmission coefficient of sound waves by 300 times when crossing the water-air interface. This report will provide multiple inspiring ideas for the application of granular matter in acoustics and electromagnetics.

KEYWORDS

Acoustic metamaterial; granular matter; acoustophoresis; dielectrophoresis

Funding Statement: The authors received no specific funding for this study.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.