# Sound Insulation Properties of Gyroids at Normal Incidence

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Gyroid is a bandgap structure that reflects and scatters specific wavelengths. This characteristic is responsible for the vibrant structural colors found in some kind of butterfly wing scales[1]. The objective of this study is to utilize the acoustic analogy of such photonic bandgap for sound insulation.

In this study, we focused on the sound insulation characteristics of a gyroid partition model with equal volume as a basic investigation. The model is described by:

$$-n < \sin 2\pi Ax \cos 2\pi y + \sin 2\pi y \cos 2\pi z + \sin 2\pi z \cos 2\pi Ax < n, \qquad (1)$$

where parameter $n$ determines the porosity. $A$ decides the compression ratio along x-axis. Figure 1(a) is Normal Gyroid ($A$ = 1), and Figure 1(b) is Compressed Gyroid ($A$ = 2). Both has the same porosity 50% ($n$ = 0.77).

The insertion loss of these models at normal incidence were calculated using the frequency domain finite element method. The periodic boundary conditions were applied in the y and z-axis directions, assuming a sound insulation wall with a thickness of 100 mm.

The numerical results are shown in Figure 2. The results indicate that both shapes exhibit high sound insulation performance for bandgap frequencies. To investigate the cause of this phenomenon, we discuss the elevation shape of the incident surface. Similar to perforated plates, there are evenly spaced holes, and its spacing matches the wavelength of the bandgap frequency. The periodicity of the elevation shape of the incident surface forms peaks or modes at the corresponding frequency because of Wood's anomaly[2]. This affects the bandgap of normal and Compressed Gyroid in common. Additionally, despite both having the same thickness, Compressed Gyroid in Figure 1(b) demonstrates improved sound insulation performance. This is because, Compressed Gyroid contains two periods in the incident direction, resulting in a higher sound insulation effect due to Wood's anomaly.

Based on these results, it is suggested that gyroids can lead to the development of effective sound insulation materials.

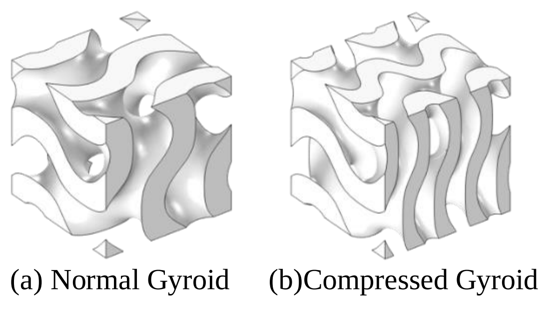


Figure 1: Two types of Gyroid models with a side length of 100 mm.

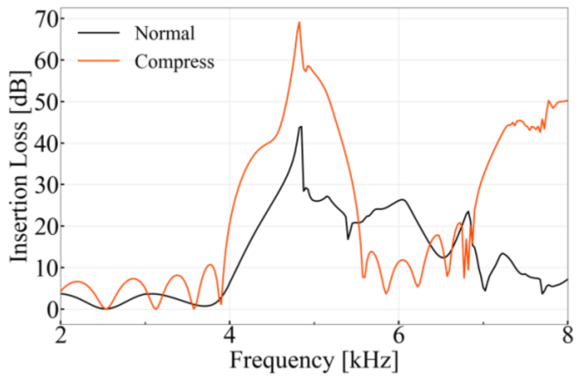


Figure 2: Insertion losses of Normal and Compressed Gyroids.

[1] Bodo D. Wilts *et al.*, *Sci. Adv.*, Vol. 3, No. 4, 2017.
[2] Hessel *et al.*, *App. Opt.*, Vol. 4, 1275-1297, 1965.