Simulation And Comparison Of A Band Gap Metamaterial Using A Relaxed Micromorphic Model

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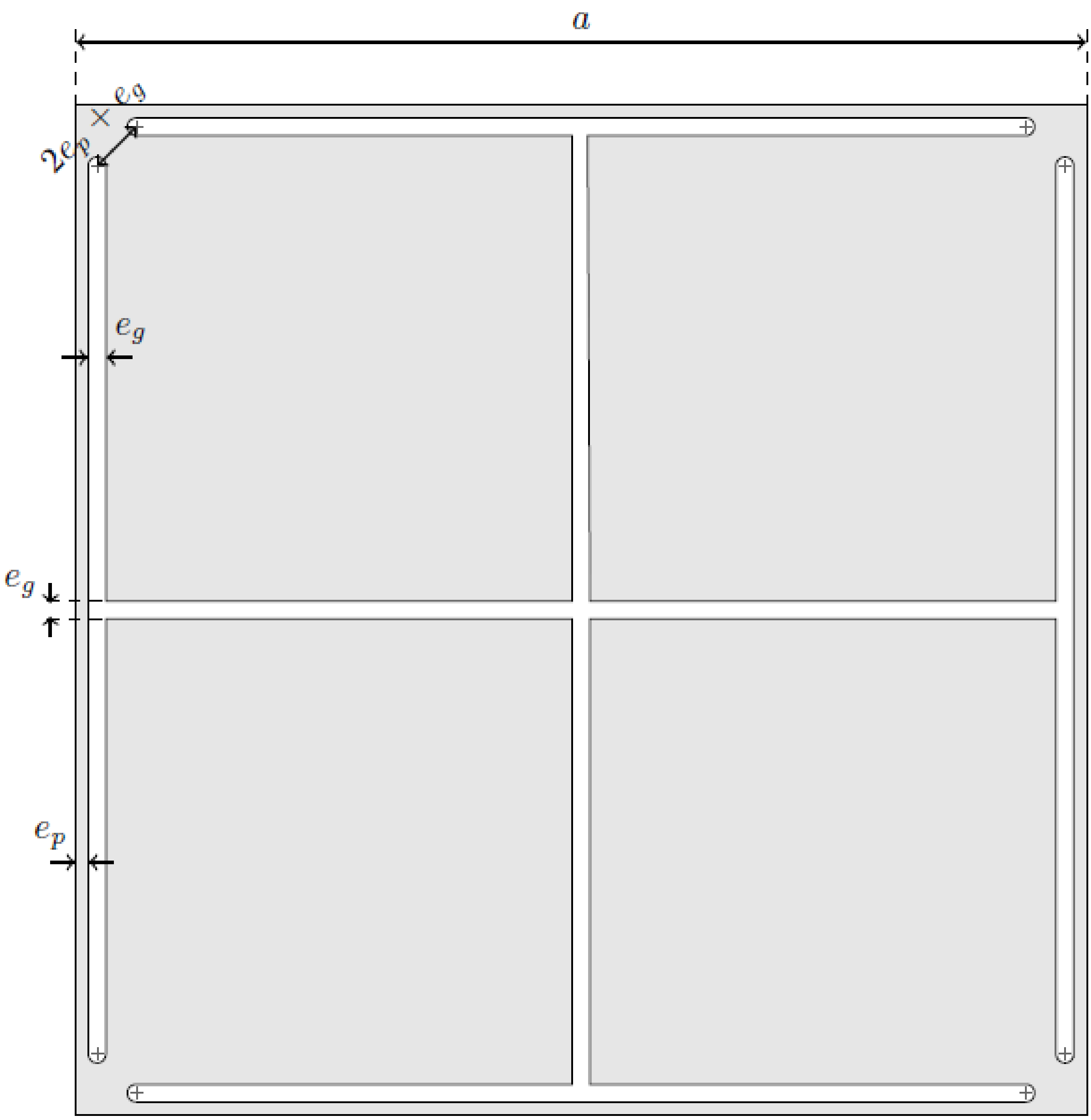
Abstract

We present here an architectured band-gap metamaterial, filtering mechanical waves in specific ranges of frequencies which, by its very specific geometry, challenges the simulation of linear elasticity problems including such elements. This unorthodox behaviour can be described as a continous medium using the relaxed micromorphic model (RMM). We compare the frequency response of a finite micro-structured plate, coupled with piezoelectric actuators, using the RMM with the classical Cauchy material model. It has been shown that the RMM is able to describe the dynamic behaviour of such systems in both low and band-gap frequencies. Such modelization can be easily inplemented in FE softwares as COMSOL Multiphysics® and significantly reduces the computational time of those systems.

Figures used in the abstract



Alliage de titane TA6V - épaisseur e

a	e_g	e_p	r_c	e	ρ	E	ν
[mm]	[mm]	[mm]	[mm]	[mm]	[kg.m^{-3}]	[GPa]	-
20	0.35	0.25	$e_g/2$	1	4400	112	0.34

Figure 1 : Cell geometry

Equilibrium equations :

$$\frac{\partial}{\partial t^2}(\rho \underline{u} - \underline{\nabla} \cdot \underline{\underline{\widehat{\sigma}}}) = \underline{\nabla} \cdot (\underline{\underline{\sigma_e}} + \underline{\underline{\sigma_s}})$$

$$\frac{\partial}{\partial t^2}\ \mathbb{J}_m : \underline{\underline{\mathrm{sym}}}\ \underline{\underline{P}} = \underline{\underline{\sigma_e}} - \underline{\underline{s}} - \underline{\underline{\mathrm{sym}}}\ \underline{\underline{\nabla}} \wedge \underline{\underline{m}}$$

$$\frac{\partial}{\partial t^2}\ \mathbb{J}_c : \underline{\underline{\mathrm{skew}}}\ \underline{\underline{P}} = \underline{\underline{\sigma_c}} - \underline{\underline{\mathrm{skew}}}\ \underline{\underline{\nabla}} \wedge \underline{\underline{m}}$$

$$\underline{\underline{\widehat{\sigma}}} = \mathbb{T}_e : \underline{\underline{\mathrm{sym}}}\ \underline{\underline{\nabla}} : \underline{u} + \mathbb{T}_c : \underline{\underline{\mathrm{skew}}}\ \underline{\underline{\nabla}} : \underline{u}$$

Stress-strain relations :

$$\underline{\underline{\sigma_e}} = \mathbb{C}_e : \underline{\underline{\mathrm{sym}}}\ (\underline{\underline{\nabla}} : \underline{u} - \underline{\underline{P}})$$

$$\underline{\underline{\sigma_c}} = \mathbb{C}_c : \underline{\underline{\mathrm{skew}}}\ (\underline{\underline{\nabla}} : \underline{u} - \underline{\underline{P}})$$

$$\underline{\underline{s}} = \mathbb{C}_m : \underline{\underline{\mathrm{sym}}}\ \underline{\underline{P}}$$

$$\underline{\underline{m}} = \mu_m L_c^2\ \underline{\underline{\nabla}} \wedge \underline{\underline{P}}$$

Figure 2 : Constitutive equations

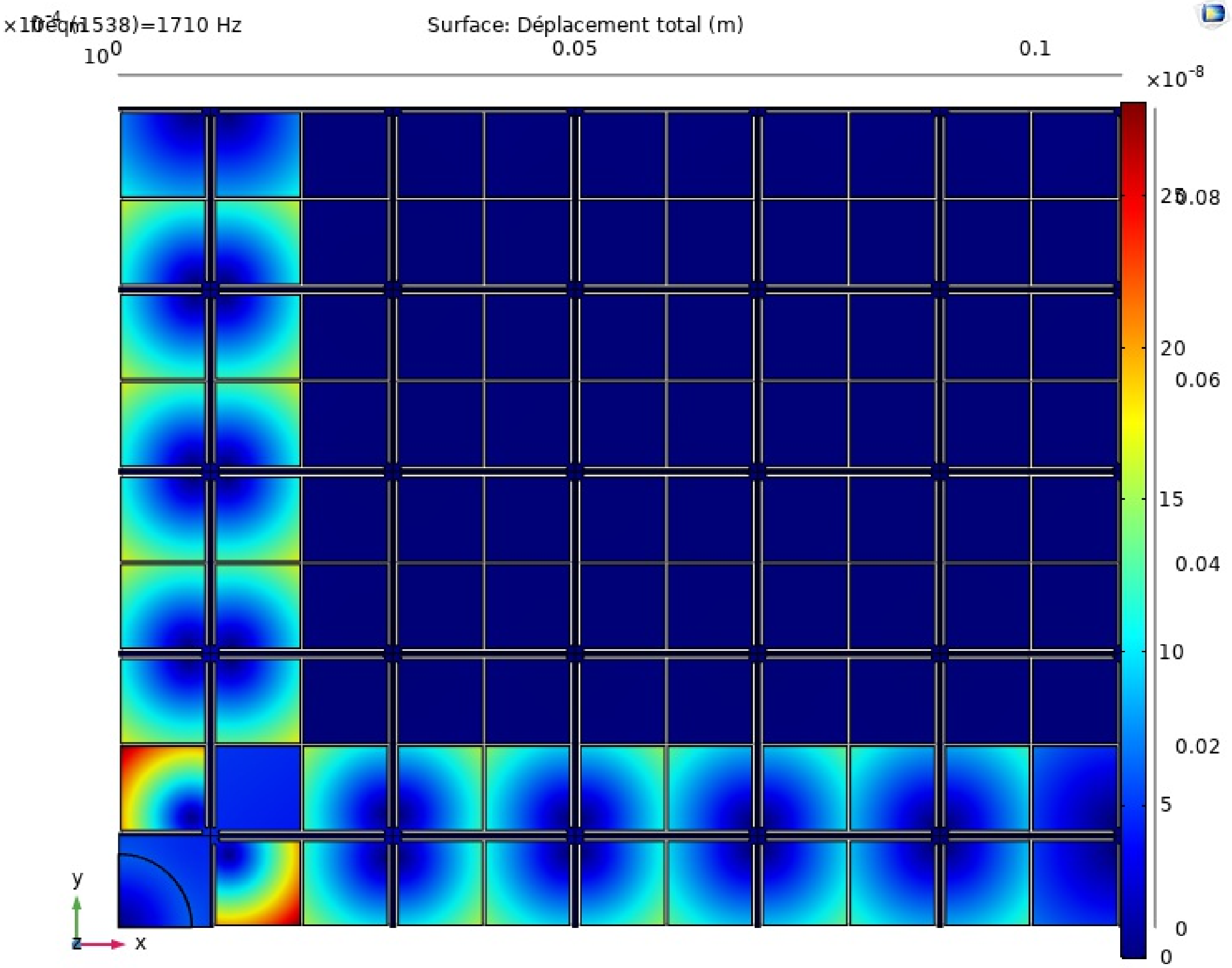


Figure 3 : Cauchy band-gap

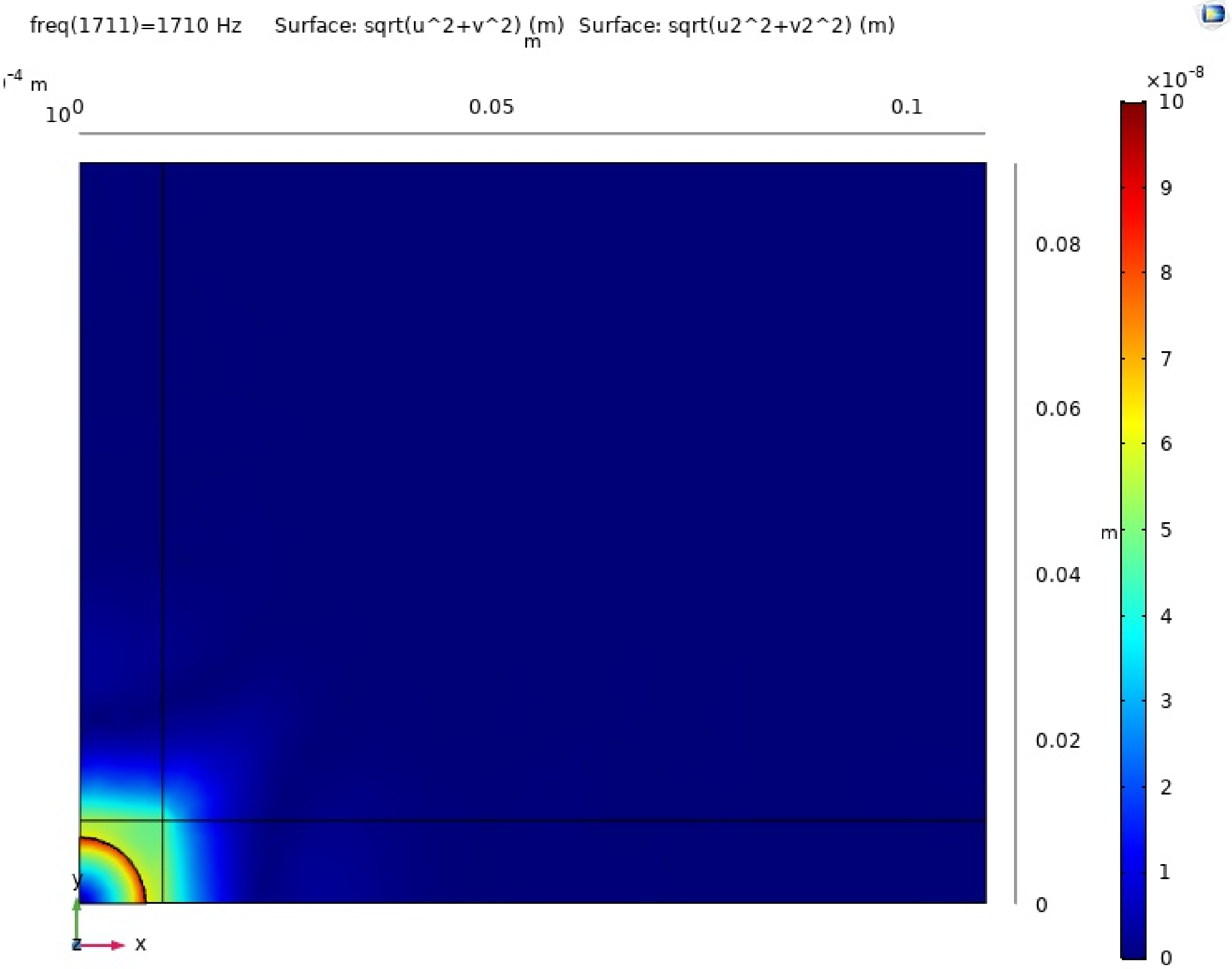


Figure 4 : Micromorphic band-gap