Modeling of Structured Materials for Sound and Vibration

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Dear Readers of Acta Acustica united with Acustica,

Noise, especially at low frequencies, is a major environmental problem across Europe. Increasingly more information is becoming available about the health impacts of noise. Urbanization, growing demand for motorized transport and inefficient urban planning are the main driving forces for environmental noise exposure. There is a pressing need for lighter, thinner and more efficient structures for the absorption of low frequency sound. Until now, porous materials have been the common choice for noise and vibration control due to their ability to dissipate sound through thermal and viscous losses and to mitigate the vibroacoustic energy through viscoelastic dissipation. However, bulky and heavy porous material treatments are required to absorb low frequency sound and dissipate low frequency vibroacoustic energy. For many years the development of noise and vibration reducing treatments has been the subject purely of acoustics research. However, recent scientific advances provide a unique and timely opportunity to bring about significant improvements in the design of noise treatments. Acoustic metamaterials and metasurfaces can revolutionize noise and vibroacoustic energy control and in many cases replace traditional treatments.

Recently the Workshop *Modelling of high performance acoustic structures – Porous media, metamaterials and sonic crystals*, organized within the framework of the COST Action DENORMS CA15125 (denorms.eu), was held in Rome 24-25 January 2017. This Action gathers more than 110 institutions across Europe and overseas and aims at bringing together researchers and engineers from the complementary but still disconnected communities of acousticians working on conventional treatments and physicists working on acoustic metamaterials and sonic crystals. The common goals are the design of lightweight, thin and multifunction noise-reducing components to be used in realistic environment and the innovation transfer towards industrial applications in various domains such as aeronautics, buildings, automotive or electronic consumers industries. This event inspired Acta Acustica united with Acustica, a leading European journal in acoustics and vibroacoustics, to publish a special section on these topics.

Revisiting the micro structure and therefore the modeling of porous materials accounting for additional resonances and dissipation mechanisms is proposed in the paper by Gaulon *et al.* [1] where the acoustic properties of liquid foam are discussed. This new sound absorbing material with the closed cell microstructure is efficient due to the resonances of the membranes that compose it. Structured materials and notably labyrinthine metamaterials presented by Krushynska *et al.* [2] also possess sound properties of usual materials. Accounting for the viscothermal losses in these structures allowsg designing porous materials with high tortuosity values possessing stop bands. The combination of usual porous materials together with periodically arranged resonant elements is then investigated in the papers by Dauchez *et al.* [3] and Gaborit *et al.* [4]. While the first presents absorption enhancement of a poroelastic layer by making use of the resonances created by periodically removing slits in it, the second proposes a transfer matrix method applicable to coatings and facings of sandwiched panels possibly incorporating periodically arranged resonant elements. The accuracy of the method is proven by studying the response of coated metaporoelastic layer. The results of these two papers show that the vibroacoustic coupling might be a highly efficient way to absorb sound energy at low frequencies. The study of dispersion relation is a key point for any periodically structured materials. Complex wavenumber/real frequency dispersion relation for flexural waves in thin plate with periodic arrangement of resonators is presented in Van Damme *et al.* [5].

Finally, analytical expressions for the amplitudes of the first and second harmonics in a one- dimensional weakly lossy nonlinear acoustic metamaterial is obtained by Zhang *et al.* [6]. This metamaterial is composed of an air-filled waveguide periodically loaded by side holes and is subjected to viscothermal as well as radiation losses. The good agreement found with numerical results paves the way to its extension to an effective double-negative metamaterial structure. Additional articles are expected for this special issue and will probably be published soon, where other micro structures are investigated, optimal configurations showing the limitations of usual porous materials are clearly stated, or use of new type of damping to mitigate the vibroacoustic energy is suggested.

References

[1] C. Gaulon, J. Pierre, V. Leroy, F. Elias, C. Derec: Dissipation of ultrasonic and audible sound waves in liquid foams. Acta Acustica united with Acustica **104** (2018) 111–111.

[2] A. O. Krushynska, F. Bosia, N. M. Pugno: Labyrinthine acoustic metamaterials with space- coiling channels for low-frequency sound control Acta Acustica united with Acustica **104** (2018) 111–111.

[3] N. Dauchez, B. Nennig, O. Robin: Additional sound absorption within a poroelastic lamella network under oblique incidence Acta Acustica united with Acustica **104** (2018) 111–111.

[4] M. Gaborit, O. Dazel, J.-P. Groby, L. Schwan, T. Weisser, P. Göransson: Combining Finite-Element Model with Bloch Waves: theory and application to metaporous materials. Acta Acustica united with Acustica **104** (2018) 111–111.

[5] B. Van Damme, A. Zemp: Measuring dispersion curves for bending waves in beams: a comparison of spatial Fourier transform and inhomogeneous wave correlation. Acta Acustica united with Acustica **104** (2018) 111–111.

[6] J. Zhang, V. Romero-García, G. Theocharis, O. Richoux, V. Achilleos, D. J. Frantzeskakis: Second-Harmonic Generation in acoustic waveguides loaded with an array of side holes. Acta Acustica united with Acustica **104** (2018) 111–111.

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