Acoustics of Porous Materials: Recent Advances Relating to Modelling, Characterization and New Materials

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Dear Readers of Acta Acustica united with Acustica,

Recent advances in mathematical theory, numerical modelling and signal processing have enabled a number of sophisticated methods for the prediction and measurement of the acoustical properties of porous media to be developed. These results impact on the fields of general acoustics, noise and vibration control, polymer extrusion, pharmaceutics, medical research, soils and underwater sediment research. Although a considerable amount of related work has been carried out since 1940s, there are still a number of significant challenges associated with modelling of the acoustical behaviour of porous materials with heterogeneous structure, complicated shape and/or unconsolidated elastic frame. Other problems concern the efficiency, stability and convergence of numerical methods that are used to predict the efficiency of single porous layers and their composites. In addition, new classes of porous materials have recently emerged. These are auxetic foams, materials with double porosity, inclusions and anisotropic pore structure. The acoustical behaviour of these materials is yet to be fully understood and practically exploited.

The aims of this special section of the journal are: (i) to present the most up-to-date developments in modelling, characterisation and applications of acoustic porous media, (ii) to communicate the advances in acoustics of porous media research to adjacent disciplines concerned with material technology, (iii) to discuss future challenges for this area of research.

This section is a compilation of eight invited papers from well-known and emerging talented researchers working on acoustics of porous media. The first three papers in this section are mainly theoretical, the next three papers are largely numerical and the last two papers focus mainly on new materials and their applications. The first paper by German Maximov presents a new unified theory of sound propagation in porous media. The author uses the Hamilton's and Onsager's variational principles to derive a system of Biot-type equations that takes into account the fluid shear viscosity relaxation, thermal conductivity and expansion coefficients. This theory predicts the existence of two shear propagation modes

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in addition to the well-known longitudinal modes derived in the original Biot's work. The second paper by Vincent Tournat and Vitalyi Gusev is focused on the acoustical and mechanical behaviour of unconsolidated granular media. The authors present state-of-art models and experimental data to illustrate how sound propagation in these media is controlled by the material state and by the nature of the incident sound wave. The third paper is by Diego Turo and Olga Umnova. The authors propose a model that can be used for time-domain calculations of the sound field in materials with varying pore shape. The new model is based on two viscous and two thermal relaxation times that are selected to match the low and high frequency behaviour of the complex dynamic density and compressibility of fluid in the material pores. The fourth paper is by Laurens Boeckx *et al.* who present an emerging technique that allows the assessment of the macroscopic properties of a material from the knowledge of its microscopic morphology. The authors study the relations between the characteristics of the oscillatory flow of air in a representative volume of porous medium (a unit cell), cell volume, polydispersity, pore size, pore connections and the resultant acoustical behaviour. In the fifth paper, Olivier Dazel *et al.* propose an original, efficient numerical method for solving the vibro-acoustic coupling problems between layers of poro-elastic materials. The proposed method is based on classical concept of substructuring that is applied to a class of frequency dependent problems. The next paper by Peter Göransson *et al.* discusses the effects of the porous structure anisotropy on the global acoustical behaviour of a porous medium. A particular emphasis is given here to the case when the porous medium is composed of multiple layers coupled to a vibrating plate. The seventh paper by Imen Chekkal *et al.* is concerned with the combined elastic and acoustical properties of auxetic foam, i.e. foam which can exhibit a negative Poisson's ratio. The eighth paper by Emmanuel Gourdon *et al.* presents predictions and measurements of the absorption properties of porous materials with porous inclusions of another nature. This technique is limited so far to isotropic materials.

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