Acoustic metafluids based on random microstructure networks

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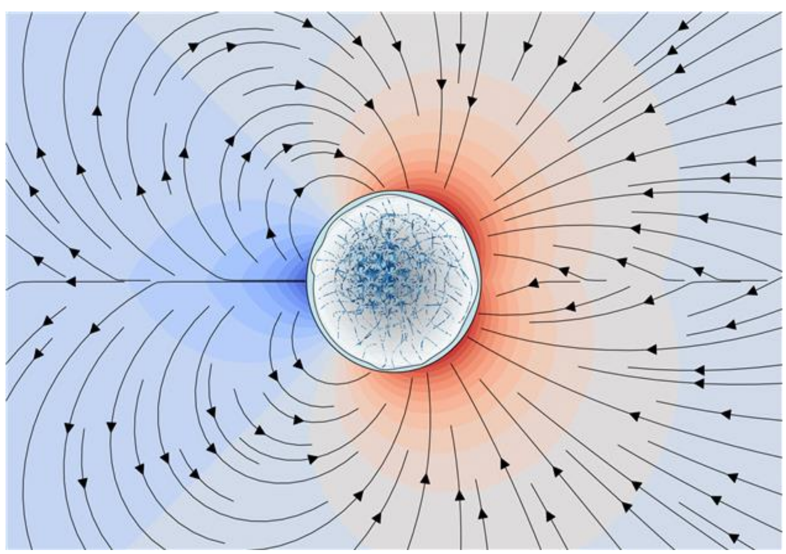
In metamaterials, the interaction between waves and matter leads to unusual wave-propagating properties of the medium, which can be used for various purposes [1]. In acoustic metamaterials, the parameters that determine sound propagation, i.e., the effective compressibility χ and density ρ of the wave-carrying medium, can become simultaneously negative in certain frequency windows due to resonance effects of sub-wavelength inclusions [1,2,3]. In our work [3] we focus on irregularly shaped inclusions - micro-oscillators – that are allowed to be randomly distributed throughout the host fluid and have irregular modal shapes. We show that the metafluid concept need not necessarily be based on position periodicity or correlation of the suspended micro-oscillators, and in this case not even on ideally designed micro-oscillators. We formulate the detailed operating principle of such a metafluid model, give explicit formulas for its effective dynamic moduli in terms of the modal structure of the micro-oscillators, and discuss basic practical issues of performance optimization in terms of their mass and size. In our model the micro-oscillators consist of point masses connected by harmonic potentials. Further we discuss how the amount and distribution of such connections affects the effectiveness of the micro-oscillators in modification of apparent acoustic parameters of the fluid. It turns out that the so called floppy-modes, which appear at very low frequencies due to under-constrained regions in the system [4], can have a substantial effect on acoustic parameters of the medium. This makes them acoustically accessible and additionally the absence of need for an intricately designed structure brings experimental realizations that much closer.



References

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