The meaning of acoustic waves in our everyday life goes far beyond the common understanding that is something what we simply hear. For example, at low frequencies, below our hearing threshold there are infrasounds which are of great importance in seismography and animal communication. On the other hand, jumping over the upper hearing threshold we find broad spectrum of frequencies, which are crucial in medical imagining (ultrasounds), telecommunication (hypersounds) and thermal transport (heat). Sound, similarly as light, in addition to its wave-like nature has a particle-like picture. Indeed, sound can be described by means of quasi-particles - **phonons -** which are quanta of the vibrational energy. Phonons as photons and electrons are carriers of energy, momentum and information. However, they are an immanent attribute of the condensed matter and cannot exist in vacuum.

The propagation of phonons, namely their dispersion relation and lifetime, can be effectively controlled by means Phononic Crystals (PnCs). PnCs are novel and exciting class of synthetic periodic materials, where the motif differing form the matrix in terms of mechanical properties is repeated in one-, two- or three-dimensions. The most prominent feature of PnCs, unprecedented in homogenous materials, is the acoustic stop-band (band-gap). This range of frequencies in which phonons cannot propagate through PnCs can be tuned by the structure period, symmetry, sizes and materials. Scaling PnCs to the hypersonic/GHz regime brings us to the structures of the feature size smaller than micrometer. What is more, the corresponding wavelengths of phonons fall into the range of visible light. As a consequence phonons in hypersonic PnCs can be measured by variety of visible light spectroscopies.

Among the other techniques Brillouin light scattering (BLS) is fully non-destructive, contactless technique which allows measuring phonon dispersions in PnCs. BLS probes the shift of the light frequency resulting from the interaction of photons with thermally populated phonons. Although useful, BLS has a clear bottleneck – long measurement time being a consequence of a weak scattering efficiency. This disadvantage becomes even more apparent in the case of the nanostructured materials of small volumes and risk of overheating and damage.

In this project we aim at the significant advancement in the instrumentation by combing the advantages of two approaches in phonon detection: spontaneous BLS and pump-probe picoacoustics. The expected breakthrough of the project is to enhance (at least one order of magnitude) the BLS signal from the materials of ultra-small volume and thereby shortening the acquisition time. In particular, we will adapt this technique to thin membranes and furthermore to two-dimensional PnCs fabricated on membranes. We want to establish a comprehensive methodology based on Brillouin spectroscopy extending its capabilities. Namely, this new approach will be an experimental platform merging measurements of the dispersion relation, phonon lifetime, transmission/reflection coefficients from nanostructured functional systems. The study of phonon confinement in the PnCs, PnC cavities and waveguides, topological PnCs, the role of local/contact resonances and finally the disorder are altogether highly essential for the recent efforts in developing sources, guiding and processing of GHz coherent phonons. In perspective, the developed and established pump-BLS technique can be adapted for a fast and contactless elastography of biological samples.