Mechanical metamaterials are structures that can exhibit unusual mechanical properties based primarily on their design. Over the last thirty years, this class of structures has been intensively studied by researchers working in the field of material science which stems from an enormous commercial appeal that such materials have to offer. Some of the most commonly studied unusual mechanical properties, that make mechanical metamaterials so useful from the point of view of numerous applications and superior in comparison to a vast majority of conventional materials, are the negative Poisson's ratio (auxetic behaviour), negative stiffness and negative compressibility. As an example, the most popular of these properties, i.e. auxetic behaviour, characterises structures that get thicker upon being stretched. Conversely, such structures get thinner upon being compressed. However, despite numerous advantages, a majority of known mechanical metamaterials share several limitations. First of all, mechanical properties of such structures typically cannot be easily modified once the structure is fabricated. Thus, from the perspective of the needs of the industry, it is essential to propose novel active mechanical metamaterials that could significantly change their properties based on the change in the external stimulus that does not require a direct contact with the mechanical metamaterial. One of the most promising ideas related to this concept corresponds to the use of magneto-mechanical metamaterials that can be controlled via the external magnetic field. In addition, the potential of mechanical properties to exhibit desired mechanical properties is typically demonstrated at the macro-scale. However, in the case of many modern applications such as novel biomedical devices and flexible electronics, it would be essential to construct such functional metamaterials at a much lower scale with the emphasis on the micro-scale.

In view of the above, in the first part of the project, a novel micro-scale magneto-mechanical metamaterial will be proposed. After being fabricated at the micro-scale, it will be demonstrated that such system can undergo a significant transition in its mechanical properties such as the Poisson's ratio and stiffness based solely on the variation in the magnitude of the external magnetic field. It will be also demonstrated that in addition to the control over the mechanical properties, the proposed active structure makes it possible to control the wave propagation properties of the system with an emphasis on the phononic band gap formation. Thus, the active mechanical metamaterial proposed in this part of the project will be a perfect candidate to be used in a variety of modern applications, where active micro-scale structures are of great significance, e.g. modern biomedical devices, vibration dampers etc.

In the second part of the project, results related to the novel mechanical metamaterial proposed in the first part will be used in order to design a specific application that could be very useful from the perspective of the modern microrobotics. More specifically, it will be demonstrated that it is possible to construct a multifunctional micro-scale device, controlled remotely by the magnitude and the orientation of the external magnetic field, that is capable of performing specific tasks. For example, it will be shown that such device can interact with smaller external objects by grabbing them and translating to the desired predefined location in space. Such ability as well as many other potential features would certainly be very interesting for researchers working in the field of materials science as well as in the related fields.

It is expected that the proposed project related to the design, characterisation and fabrication of micro-scale truly active mechanical metamaterials is a very timely direction of studies that is likely to significantly contribute to the current state of the art in the field of mechanical metamaterials. The proposed results are also likely to be very useful from the perspective of a plethora of applications ranging from novel protective to medical devices.