Although thermoelectric effects have been discover in the 19th century, today many of the world's leading laboratories and research institutions are still conducting intensive research, which have in purpose to find new materials with better thermoelectric efficiency and performance and to find universal ways to improve their characteristics. The thermoelectric effect is frequently described as a process resulting in the mutual conversion of thermal and electrical energy. In other words, electricity can be generated if there is a temperature difference between two sides of a material; or a temperature difference between two sides of a material can be created when electrical current flows through it. These fascinating properties of thermoelectric materials are widely used in real-life applications, and there are two types of devices that operate based on thermoelectric phenomena: thermoelectric generators (generate electric power in the presence of temperature gradient) and thermoelectric refrigerators (generate cooling power in the presence of electrical power). Thermoelectric generators are environmentally friendly energy sources and it is one of the reason why it is important to develop their research. However, one of the most interesting and encouraging application of thermoelectric power generators is in long-term space missions; for example, in the recent Mars mission, the rover Perseverance was equipped with thermoelectric power system.

There are two types of thermoelectric effects, longitudinal (the direction of the temperature gradient is parallel to the direction of electrical field) and transverse (the direction of the temperature gradient is perpendicular to the direction of electrical field). Almost all thermoelectric devices that are used in practice have longitudinal thermoelectric effects in their operating principle. Transverse thermoelectric effects, on the other hand, have not been studied so intensively, because it was thought that their application potential was less than that of the longitudinal ones. In recent years, however, interest in transverse thermoelectric effects has increased significantly as large magnitudes of transverse thermoelectric effects have been discovered in topological semimetals and materials with axis-dependent conduction polarity, so-called goniopolar materials. Both groups are very promising as transverse thermoelectric materials, but the physical mechanism behind them are not well understood. Therefore, in the present project we would like to investigate several materials belonging to these groups. We have selected three subgroups of materials to be studied in the project, these are non-magnetic topological semimetals, magnetic topological semimetals and goniopolar materials. These selection was made on the basis of the mechanisms believed to be responsible for large transverse thermoelectric effects in these three groups. The mechanism is believed to be different in each group. To achieve the research goal, we plan to realize several tasks. Firstly, we will synthesise high-quality single crystals of the selected materials and then investigate their thermoelectric properties. In order to propose the mechanisms of transverse thermoelectric effects in the studied materials, we will perform theoretical calculations of electronic structure and investigate their Fermi surfacers experimentally. Finally, based on the results obtained on single crystalline materials, we will select material with the best thermoelectric performance and then synthesize it in polycrystalline form and study it transverse thermoelectric properties, since polycrystalline materials have a higher application potential compared to single crystals.

We believe that the successful implementation of this project will provide a large amount of valuable new data that will help in understanding the correlations between electronic structure singularities and transverse thermoelectric effects in both topological semimetals and goniopolar materials. This, in turn, will pave the way towards enhancing transverse thermoelectric performance, providing a roadmap for future improvements.