Rotational magnetocaloric effect in intermetallic compounds with a layered crystal structure as an alternative cooling solution

Heating and cooling devices such as refrigerators, air conditioners and various types of heating systems for our buildings are irreplaceable everyday equipment. The increasing exploitation of such devices leads to the increase of the energy consumption. For this reason, solutions for high energy efficiency that decrease energy consumption and environmental pollution are sought.

Among the many technical proposals for cooling devices, one of the most promising is the solution using the magnetocaloric effect (MCE). The principle of this effect is the cooling/heating of the material due to changes in the magnetic field. The main advantage of MCE-based cooling devices is their high energy efficiency, higher than the cooling methods commonly used currently. However, the commercial use of magnetocaloric refrigerators is limited due to technical difficulties associated with the design and production of the final product. The solution to these technological problems may be the rotational magnetocaloric effect (RMCE), which uses a magnetic field differently than the standard MCE effect. In the RMCE, using a static magnetic field and changing the orientation of the material relative to the magnetic field results in the cooling or heating of the material. The ability to rotate the material in the static magnetic field significantly simplifies device design, as it is not necessary to produce areas with a zero magnetic field in the device.

The aim of the Project is to search for and study new materials for the rotational magnetocaloric effect application. The proposed group of intermetallic compounds is $R(\mathrm{V,\ Mn})_6\mathrm{Sn}_6$ with the $\mathrm{HfFe}_6\mathrm{Ge}_6$-type crystal structure, which exhibits a layered arrangement of atoms. The samples will be produced using different methods, which will determine the influence of a given production method on the magnetocaloric parameters while maintaining the highest possible production efficiency of the material. The quality of the samples will be verified by structural investigation, followed by magnetic, specific heat, and transport measurements, which are necessary to determine the parameters characterizing MCE and RMCE Obtained magnetocaloric properties will be analyzed to evaluate different methods of sample production and the application potential of the tested materials.

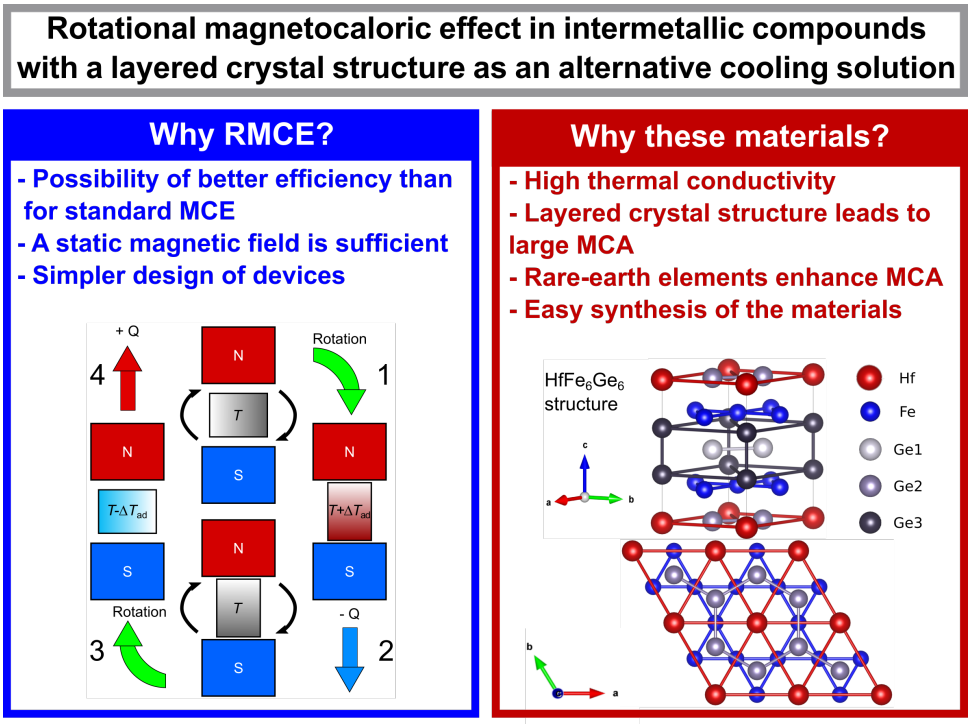

Figure: Graphical visualization of the Project concept. Left panel: visualization of the cooling process using the rotational magnetocaloric effect. Right panel: the crystal structure $\mathrm{HfFe}_6\mathrm{Ge}_6$ of the proposed intermetallic group of compounds $R(\mathrm{V,\ Mn})_6\mathrm{Sn}_6$ is presented. MCA – magnetocrystalline anisotropy, MCE – magnetocaloric effect, RMCE – rotational magnetocaloric effect.