Every day, hundreds of new devices, materials and technical solutions are presented on the market. This is obviously due to the amazing human intellect, but it would not be possible without rapid technological progress, which requires constant development of increasingly complex devices and advanced materials. Materials that deserve special attention are superconductors because they conduct electricity without losses. The applications of superconductors in technology are still limited, mainly due to the fact that they can only work at temperatures well below room temperature. However, in common use already are superconducting electromagnets generating strong magnetic fields in scientific laboratories and in medical diagnostics (magnetic resonance imaging) as well as superconducting highly sensitive measuring devices (SQUID). Currently, the most promising, due to relatively high critical temperatures, are the so-called high-temperature cuprate superconductors and iron pnictides. However, since 1993, when the superconductivity with a critical temperature $T_c = 133$ K was found in the Hg-Ba-Ca-Cu-O system, the superconductor with a higher T_c (under normal pressure) has not been found yet. A strong impulse to intensify the search for new superconductors with high critical temperatures was given by the discovery of superconductivity in H_3S in 2015 at temperatures above 200 K (under high pressure of 200 GPa). A full understanding of the superconductivity mechanism is one of the greatest challenges of modern physics. Intensive research is carried out to obtain materials with higher and higher superconducting transition temperatures. The aim of the proposed Project is, therefore, to provide new experimental data to help clarify the mechanisms governing the critical temperature of superconductors.

Using synthesis at high temperatures and under high pressure, we will synthesize samples of properly doped cuprate superconductors from the "infinite-layer" family. In these materials the crucial parameter is the distribution of charge between copper and oxygen atoms. According to this concept, obtaining a hole-doped "infinite-layer" compound should result in a material with a transition temperature to the superconducting state higher than previously observed in cuprate superconductors. In the case of iron-pnictide superconductors, it has been suggested that superconductivity is associated with spin fluctuations and nematic ordering. We will study the role of these phenomena in single crystals of compounds from the AFe_2As_2 family. To achieve the main goals, we will perform measurements using two complementary experimental techniques: nuclear magnetic resonance (NMR) and X-ray absorption spectroscopy using synchrotron (XAS).

We expect that the Project will noticeably contribute in physics, in understanding the nature of unconventional superconductivity and in material engineering – by providing new guidelines for designing superconducting materials with high critical temperatures.