„Electronic nematicity in iron-based superconductors studied by Mössbauer spectroscopy”
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DESCRIPTION FOR THE GENERAL PUBLIC

The phenomenon of superconductivity, i.e., conductivity with the null resistivity discovered in 1911 remains still somewhat mysterious and fascinating from the fundamental point of view, as it is a manifestation of quantum phenomena on a macroscopic scale. It is also important from the practical point of view, because it allows the construction of very strong magnets and extremely sensitive detectors of very weak magnetic fields based on the phenomenon of quantum interference. There is no plausible explanation of this phenomenon in the so-called high temperature superconductors.

Iron-based superconductors with the critical temperature up to 56 K were discovered in 2008 and they exhibit a complex phase diagram with multiple competing orders. In these systems, such phenomena as magnetism, crystallographic order, electron orbital order and superconductivity co-exist and compete with each other. The system can be switched between states corresponding to the above phenomena by a slight modification of its chemical composition (doping). In particular, the state of so-called electronic nematicity, characterized by the anisotropy of the electronic structure in the two-dimensional crystallographic plane a-*b*, resulting from the disturbance of local rotational symmetry and simultaneously preserved translation symmetry.

The aim of this project is to investigate the properties of the nematic phase in selected iron pnictides and chalcogenides as a function of doping (and temperature) by the Mössbauer spectroscopy. We expect to observe in the nematic phase the changes of the electronic structure of the system by observing changes in the value of the internal magnetic field and heterogeneity of the internal electric field (local symmetry of electron distribution). The Mössbauer spectroscopy, as a nuclear experimental technique, allows to measurements the above phenomena by a unique extreme sensitivity to hyperfine interactions between the resonance atom (in this case the iron atom) and the local electric and magnetic field in the material under study. It allows to study the behavior of electrons inside a superconductor disturbance of superconducting state, i.e. without the use of additional external magnetic field or electric field.

We plan to implement the above objectives through systematic study of materials characterized by the occurrence of the nematic phase and with different doping types and substitution level, e.g. electron-doping (the case of $Ba(Fe_{1-x}Co_x)_2As_2$), isovalent-doping (case of $BaFe_2(As_{1-x}P_x)_2$) and formally undoped superconductor (the case of LiFeAs). Materials from the iron-pnictides (*previously mentioned*) and iron-chalcogenides (the case of $FeTe_{1-x}Se_x$) were selected for the research. They represent the three most popular families of iron-based superconductors, i.e. "122", "111" and "11". The main research method will be the transmission Mössbauer spectroscopy on iron atoms wherein our Laboratory has been specializing for many years.

The obtained results will contribute to understanding the relationship between electronic nematicity and superconductivity. In particular, they will contribute to understanding whether the existence of the nematic phase results from a change (distortion) of the crystallographic structure, orbital charge order, or spin electron order (spin fluctuations). It may be that nematic phase is the result of the coexistence and competition of these phenomena.