Because an understanding of the mutual relationship between superconductivity and magnetism in FeAs-based materials as well as the role of antisymmetric spin-orbit coupling (ASOC) in noncentrosymmetric superconductors is the overriding goal of the project, we propose to investigate three series of FeAs-based and several noncentrosymmetric superconductors, for all materials listed below the microscopic properties remain completely unexplored up to now.

1. the 21113-series $Sr_2MFeAsO_3$ (M = Sc, Ti, V, Cr),
2. the series (Ca*n*+2(Al, Ti)*n*O3*n*, *n* = 2, 3, and 4,and
3. the 10-*n*-8 series of the formulas $Ca_{10}Pt_nAs_8$-$(Fe_2As_2)_5$, *n* = 3 or 4
4. ^{57}Fe-doped noncentrosymmetric superconductors $LaNiC_2$, Re_6Zr, Th_7T_3 (T = Fe, Co, Rh, Ir).

Investigating the mentioned above materials, we will look for answers of the questions:

- *Does phonon spectrum change at the transition to a superconducting state?*
- *What is the immediate environment of the atoms involved in the superconductivity?*
- *Do magnetic interactions (including the spin density wave) associate with the superconductivity?*
- *What is the role of magnetic interactions and what is the relationship between different magnetic interactions in the superconducting state?*

Taking into account the need to clarify the mechanism of electron pairing in newly discovered unconventional superconductors, as well as the general directions of research in the World and at the Institute of Low Temperature and Structure Research, the Mössbauer spectroscopy was chosen as a key research method in this project.

Valuable information being to obtain is of a magnetic (hyperfine field), electric (isomer shift, quadrupole interaction) or vibrational (recoil free fraction, 2nd order Doppler shift) nature. Obviously, structural and bulk properties characterization as relevant to each particular series of superconductors, will naturally be utilized. The following issues are envisaged to study in this project: structural, magnetic properties and hyperfine interactions. In addition, we plan to perform measurements of muon spin relaxation/rotation for a few selected samples of the superconductors. We anticipate to achieve the ambitious objective of the project:

- *To determine important physical properties from the microscopic point of view, like the electron density at the Fe-position, the electric field gradient, hyperfine magnetic field distribution, local vibration modes, relaxation/fluctuation and phase transition phenomena.*
- *To explore the interplay between the superconductivity and cooperative states (such as magnetic ordering, spin fluctuation, spin density wave, exchange) in FeAs-based superconductors.*
- *To settle the role of asymmetric spin-orbit coupling versus electron-phonon coupling in noncentrosymmetric superconductors.*
- *To establish systematic characteristics of the microscopic properties for FeAs-based and noncentrosymmetric superconductors.*

The real results of the project will be the publication of scientific papers in renowned international journals and dissemination of results at national and international conferences as well as on the Internet. A large proportion of the results obtained during this project plans to use in two PhD theses and several master's diplomas.

Finally, we believe that the information obtained during the realization of this project should help us to unravel the relationship between superconductivity and different factors, involving phonons, the antisymmetric spin-orbit coupling, magnetism in Fe-based and in noncentrosymmetric superconductors. The obtained results which will contribute not only to a complete picture of the physical properties of these materials, but also to expand our knowledge of the microscopic mechanisms of pairing of electrons in unconventional superconductors.