The discovery in 2007 of the first three-dimensional (3D) topological system gave impetus to extremely dynamic development of a new branch of physics nicknamed physics of topological matter. Advanced experimental and theoretical studies on various topological phases is currently carried out by physicists and chemists, materials experts and engineers in almost every major scientific center in the world. Their main interest is focused at 3D insulators and semimetals, in which non-trivial metallic states are protected against perturbations by powerful topological constrains.

Essentially, most of the well-studied topological materials are non-magnetic in nature. **Our present proposal aims at discovering novel topological phases in which magnetism significantly affects the transport properties governed by non-trivial topology.** Taking advantage from our experience and knowledge gained during our preceding work on non-magnetic topological systems, we intend to **combine state-of-the-art experimental methodology with advanced theoretical calculations** from first principles, in order to develop a reliable procedure for identification of new emergent quantum states, such as higher order topological insulator phase (HOTI), axion topological state, muliti-fermionic Dirac/Weyl phases, etc., the existence of which has recently been predicted by means of theoretical considerations.

Due to pioneering nature of the research tasks to be undertaken, their actual course will be moderated on an on-going basis by both the results achieved and the current literature reports. Our experimental activities will include synthesis of high-quality single crystals, detailed measurements of their structural, magnetic and transport properties under multicritical conditions (low temperatures, strong magnetic fields, high pressures), as well as advanced spectroscopic studies (angle-, spin- and time-resolved photoemission, muon spin rotation spectroscopy, Moessbauer spectroscopy). At first, we plan to perform detailed investigations of a family of Eu-based ternaries with chemical composition EuM_2X_2, where M stands for a p-electron metal (M = Zn, Cd, In, Sn), while X represents a pnictogen atom (X = P, As, Sb). A few of these compounds have recently been found theoretically as best candidates for systems harboring HOTI phase coexisting with axion states. Remarkably, the first preliminary experimental reports seem to confirm those trilling predictions. Another material that we are going to investigate in the first months of running the project is $EuMg_2Bi_2$ that has recently been described in the literature as an example of multifermionic topological systems. Our choice of these materials was dictated not only by the results of theoretical studies, but also by the fact that all of them can be obtained in the form of relatively large, stable, stoichiometric single crystals, and their crystal structure is fairly simple and thus convenient for DFT calculations and theoretical modeling. Furthermore, the magnetism in these compounds is extremely strong due to very high magnetic moment of Eu^{2+} ions, and their magnetic behavior is fairly easy to evaluate owing to its spin-only nature.

The expected outcome of the project will be initiation of new original research pathways in the blooming physics of topological matter. Exploration and deep understanding the role magnetism plays in magnetic topological insulators and semimetals, in particular its effect on their extraordinary electrical transport properties, will not only bring about a substantial cognitive input, but potentially will bear some importance for their practical applications of such materials in design and fabrication of memory units, sensors, magnetic switches and other spintronic devices, or possibly also novel devices for quantum computing.