DESCRIPTION FOR THE GENERAL PUBLIC

Determination of band structure of crystals of selected intermetallic compounds which consist of cerium is the subject of our project. Namely, we would like to make studies on polycrystalline samples of $CeRhSb_{1-x}Sn_x$ family and on single crystals of $CeFe_4As_{12}$ and $CeCoIn_5$ compounds. Such systems have got many unusual physical properties which are caused by presence of 4f cerium electrons. Such electrons interact strongly between each other as well as they interact with carriers from conduction band, which is called as a hybridization. Aforementioned interaction results in nontrivial magnetic and transport properties which are realized in specific materials. Electrons, which are moving in described materials, often behave like they would have masses many times (sometimes even 1000 times) greater than mass of a free electron. Among the set of interesting phenomena, within that project, we would like to deal with problem of existence of Kondo insulators. Such materials behave like semiconductors with a very narrow gap (the width of a gap is about 1 K) which overlaps the chemical potential. Moreover, theoretical calculations which base on the density functional theory, predict that one material, which we are going to study, can be topological insulator. Bulk of such a material does not conduct an electrical current, because of the gap in the band structure. Although transport of the charge carriers on the surface is similar to that in graphene, where the carriers have high mobility and dispersion like photons with zero rest mass. In some systems, which reveal Kondo insulation, one can observe formation of quantum critical points. Such phase transition goes in absolute zero temperature, so that quantum fluctuations are not involved, in distinction of classical phase transition. Band structure can be conveniently probed by means of photoelectron spectroscopy, which bases on photoelectric effect. In measurements, which we are going to perform, the electrons were excited from samples with application of x-rays or ultraviolet. From the measurements we will obtain band structure, thus we will have information about existence and width of forbidden gaps as well as about effective masses of carriers.

Projected research has fundamental character and can significantly boost the development of solid state physics. Direct, experimental observation of a narrow gap in a Kondo insulators poses a serious challenge for experimental physics. On the other hand, the band structure, obtained from experiments, will state a test for theoretical models which describe strongly correlated electrons. Beyond the fundamental aspects, studied materials have beneficial properties for practical applications, e.g, in thermoelectric devices.