UEFISCDI PROJECT PN-III-P4-ID-PCE-2016-0534
CONTRACT 195/2017

Investigation of the Phase Diagram of Selected Materials by µSR and µSR under Pressure.

PROJECT SUMMARY

The proposed project is intended to cover a 2.5 year period. During the project we use, among traditional techniques, µSR and µSR under pressure for the study of selected intermetallic compounds. In a µSR experiment, a 100 % polarized muon (spin 1/2 elementary particles) beam is implanted into the investigated sample where they stop in interstitial crystallographic positions and their spin performs Larmor precession around the local field at the place where they come at rest. Muons disintegrate with a lifetime of 2.2 µs, emitting a positron preferentially along the muon spin at the moment of disintegration. By registering, with detectors placed around the sample, the spatial distribution of the emitted positrons, one can obtain valuable information about the value of the local field, field distribution and field dynamics.

The aim of this work is to investigate:

a) the ground state of selected compounds at ambient pressure.

Effort will be invested for a better understanding of the ***helical and skyrmions magnetic structures****, in MnSi, as "seen" in µSR experiments. Moreover, it is in our intention to observe and characterize the electrical current induced motion of the skyrmion lattice,* firstly evidenced in MnSi by SANS experiments, for a better understanding of such an out of the ordinary magnetic ground state. Electrical current induced motion of the skyrmion lattice resembles the current-induced motion of superconducting vortices in transverse-field µSR experiments. No effect of the electrical current is expected to be observed in the helical and conical phases. On the other hand, a large effect is expected for the skyrmion phase because the depinning of the skyrmions by the current should strongly influence the field distributions/dynamics.

In ***the*** $Mn_{1-x}Rh_xGe$ ***system***, magnetization and neutron diffraction experiments have indicated that the Rh substitution expands the lattice and induces non-magnetic holes in the Mn sub-lattice, leading to the collapse of the long range (LR) helical order at $x \sim 0.5$ (Quantum Critical Point, (QCP) while the $x = 0.5$ sample shows unconventional SC with $T_c = 4.5$ K at ambient pressure. µSR is an ideal tool to investigate fluctuations of the magnetic moments, via the relaxation induced in the time evolution of the muon ensemble: short range helixes and/or ferromagnetic correlations are expected to survive, for concentrations just above the QCP. µSR is

usually able to separate and characterize the static/dynamic contributions. For the $x = 1$ end of the series, µSR can again be used as a problem solver, by tracking very small static local fields at the onset of SC.

$Li_2ScMo_3O_8$ and $Li_2InMo_3O_8$ have a half-filled 2D triangular lattice formed by Mo_3 clusters, sandwiched by two adjacent Li_2Sc (or Li_2In) layers. Our µSR experiments will shed more light on the ground state of these compounds, not yet clearly explained from macroscopic measurements.

Investigation of the phase diagram of Na_xCoO_2 synthesized by electrochemical reaction. Interestingly, the phase diagram of Na_xCoO_2 depends on the preparation method. In order to be able to correlate experimental/theoretical investigations, a careful description of the phase diagram is needed. The homogeneity of the samples is better if prepared by electrochemical reaction and less good if prepared by the solid state reaction technique and chemical deintercalation. µSR will be employed to describe the ground state of these new prepared samples.

b) the pressure dependence of the ground state's physical properties of selected compounds.

$Sr1_{-x}Ca_xCo_2P_2$ compounds crystallize in the same structure as the 122 iron-arsenide superconductors, does not show unconventional superconductivity but exhibit an interesting magnetic transition with the structural change: the crystal structure changes from uncollapsed tetragonal for $x = 0$ to collapsed tetragonal for $x = 1$. The system evolves from a nonmagnetic metallic ground state to an AF metallic ground state through a crossover composition regime at $x > 0.5$. Then, in the x range between 0.8 and 0.9, the system manifests a FM – like ground state within which the magnetic ordering temperature is highest at x ~ 0.9. For the samples with $x > 0.9$, an AF ground state reappears. The appearance of the magnetic ordered phase and the formation of the long-range order are also found to be strongly correlated with the distance between the nearest neighboring Co ions in the adjacent Co_2P_2 planes (dCo−Co). We plan to investigate the relationship between the nature of magnetic order and the Co−Co distance in these samples, by performing µSR studies under hydrostatic pressure and to clarify the relation between the reduction of the Co – Co distances and the suppression of magnetism in the $x = 1$ sample at high pressures.

We will also search for materials with high magnetocaloric effect **(MCE), in the *RT_2*** series: cubic Laves phases compounds RT_2 with T = Fe or Co have relatively simple crystallographic and magnetic structures. Some of these compounds exhibit significant magnetocaloric effect. In recent years, interest toward the MCE has grown enormously due to feasible application in magnetic refrigeration. We will try to get insight on the right conditions for having a good MCE.

Only a limited number of samples of samples were presented, others will be added on the way. By doing this, we are open to further collaborations (using µSR as problem solver) and investigate freshly new discovered samples (i.e. samples with publishing potential in high ranking journals) and to find new physics. This worked successfully for our last two projects, (IDEI 2008, IDEI 2011, 43 ISI articles) almost half of the papers published being related with samples not explicitly specified but stated as "other added on the way" in the 2 previous proposals and linked to the proposals by proper acknowledgements. Experiments will be performed at the different beam-lines of the LMU (Laboratory for Muon Spin Spectroscopy) of PSI (Paul Scherrer Institute) Villigen, SWITZERLAND and using the facilities of the Ioan Ursu Institute, Babes – Bolyai University, Cluj – Napoca, ROMANIA.