TECHNISCHE UNIVERSITÄT WIEN
a.o.Univ.Prof.Dr. Herwig Michor
INSTITUT FÜR FESTKÖRPERPHYSIK
WIEDNER HAUPTSTRASSE 8-10/138
A-1040 WIEN
TEL.: 58801/13140

Prof. Jan Kratochvil
Dean
Faculty of Mathematics and Physics
Charles University Prague
Ke Karlovu 3
121 16 Praha 2

10.09.2019

Review on the doctoral thesis
"Ground state investigations of Ce and U intermetallic compounds "
by Mr. Attila Bartha

The thesis submitted by Attila Bartha concerns the electronic ground state formation in intermetallic cerium and uranium based strongly correlated electron systems. These systems attract sustained interest due to the rich variety of phenomena emerging from the competition between various types of cerium/uranium on-site and inter-site interactions, i.e. on-site Kondo correlations between 4f/5f and conduction electrons as well as crystalline electric field effects and inter-site RKKY-type interactions. The focus of the present thesis is an experimental investigation of two cerium systems, $Ce_2\mathit{T}In_8$ and $CePd_2\mathit{T}_3$, and one uranium system U_nRhIn_{3n+2}. A specific interest on the indium based systems studied in this thesis with formula $(Ce,U)_n\mathit{T}In_{3n+2}$ is their quasi-two-dimensional arrangement of alternating layers build from $\mathit{T}In_2$ and n units of $(Ce,U)In_3$.

The first part of the thesis comprises two chapters with a brief overview on relevant theoretical concepts and the experimental techniques applied in this work.

The main part of the thesis is devoted to the original experimental research which is based on an impressive variety of experimental techniques comprising single crystal growth, basic characterization by X-ray and microprobe studies, macroscopic bulk studies of physical properties such as electrical resistivity, specific heat and orientation dependent magnetisation measurements, including detailed studies of the de Haas-van Alphen effect in $URhIn_5$, to single crystal neutron diffraction studies of the magnetic structure of $URhIn_5$ and U_2RhIn_8.

Novel and relevant scientific results presented in the thesis are: (i) detailed, thoroughly analysed single crystal magnetoresistance and Hall resistance studies of Ce_2IrIn_8 and very comprehensive magnetic field orientation dependent heat capacity and magnetisation studies of Ce_2RhIn_8 which finally result in a three-dimensional magnetic field-orientation-temperature phase diagram of this compound and, thus, on field induced metamagnetic phases of its magnetic ground state as well as information on its magnetic anisotropy; (ii) Bridgeman based single crystal growth was successfully worked out for $CePd_2Ga_3$ and $CePd_2Zn_3$ and, based on this progress, single crystal magnetisation studies of $CePd_2Ga_3$ are used to determine critical exponents, which are finally compared to simple models and, for $CePd_2Zn_3$, an initial characterisation of the magnetic ground state and its temperature and field dependent magnetic phase diagram is presented; (iii) two structurally related uranium compounds $URhIn_5$ and U_2RhIn_8 have been deeply investigated by means of single crystal neutron diffraction studies and their commensurate antiferromagnetic ground states are verified. For $URhIn_5$, detailed studies and discussions of de Haas-van Alphen oscillations are presented and valuable new information on the Fermi surface topology is obtained. For each of the compounds investigated in the course of this thesis project new and relevant information on grounds state features of these systems has been achieved. Five papers published in refereed journal have emerged so far from these results, including one published in Physical Review B.

There are, of course, a few points of critique to be mentioned, e.g., with regard to the basal plane rotation scans of the magnetization of Ce_2RhIn_8 one should have considered potential artefacts of an out-of-plane component due to a most likely small misalignment of the crystal. For $CePd_2Ga_3$ and $CePd_2Zn_3$ it would have been worth to analyse crystalline electric field effects in closer detail and to consider the limitations of the models used to conclude on a 3D Ising behaviour, even though, the easy orientation is concluded to be the basal plane. For a few aspects of the discussions, corresponding literature reviews could have been more comprehensive.

To summarise, Attila Bartha demonstrated with this thesis his ability to perform creative scientific work. He combines the experimental skill to grow high-quality single crystals and to apply a variety of macro- and microscopic experimental measurement techniques with the ability to apply proper theoretical concepts for the interpretation and modelling of the experimental results and thereby achieved a relevant scientific progress for each of the systems studied in his work.

Vienna, Sept. 10th, 2019

A.o. Univ. Prof. Dr. Herwig Michor

Questions:

1) In chapter 3.2.2, $CePd_2Ga_3$ is studied with respect to the critical exponents of the ferromagnetic phase transition and it is concluded that the experiment most closely matches the 3D Ising model. The analysis of the magnetic anisotropy however proposes the basal plane to be the easy orientation of the magnetisation, i.e. would be in favour of the 3D XY case. What are obvious simplifications of the models which could put these contradictive conclusions into perspective?

2) What other experimental studies and techniques (apart from those used in course of this thesis work) could be most important to obtain new and complementary information on the electronic (magnetic) ground state of the investigated cerium compounds?

3) In sections on $(Ce,U)_n TIn_{3n+2}$-type systems, layered compounds with different stacking types are discussed. Such compounds are known to display rather limited translation symmetry due to non-periodic, partially correlated planar defects as well as coexistence of minority and majority structural pattern and segregation of polytypic phases. Detailed studies of such aspects would, of course, have been another thesis project. The question is, whether some of the already obtained experimental results could relate to the discrepancies between the idealized structure model and the less perfect real structures? Which specific results could support a high degree of translation symmetry of the respective compound?