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Referee's opinion on the habilitation thesis of RNDr. Jiří Pospíšil Ph.D. entitled "The role of single crystals in materials research" and his scientific achievements

The short version of the habilitation thesis of RNDr. Jiří Pospíšil Ph.D. consists of 48 pages (in which its main part (7 chapters) is from page 4 to page 37). It is based on 18 scientific publications for which the author was an author or co-author, published during 2013-2021 (in which 10 in Physical Review B, 3 in Journal of Physical Society of Japan and 5 in other journals). The reprints of those publications were included in the Appendix of the long version of the habilitation thesis (consisted of 254 pages).

The author's research mainly concerns single crystals of the actinide-based systems, especially emphasizing materials with highly anisotropic properties. The author has focused on the improvements in the growth technology of single crystals of new materials at the Department of Condensed Matter Physics (DCMP), Faculty of Mathematics and Physics (FMP), Charles University (CUNI). Subsequently, he grew high-quality single-crystals of selected compounds and studied their phase diagrams, which involve the evolution of electronic and lattice properties. His particular interest was focused on 5f-electron magnetism in uranium-based intermetallics and the interplay with unconventional superconductivity.. The research has been carried out in the frame work of e.g. GAČR projects as well as the international cooperation with research groups in foreign institutions in Japan, Germany, France…(e.g. during his three years postdoc stay (in Japan), short-term stays and visits).

The research has been focused on the effect of external conditions (temperature, doping, high magnetic field, high pressure) on magnetism and related electronic phenomena in selected uranium-based intermetallics. One of goals of the work was to investigate the evolution of ferromagnetic ordering in these 5*f*-electron itinerant ferromagnets with variations of external parameters and to determine the phase borderlines and critical points in the phase diagrams.

The main part of the habilitation thesis consists of 7 chapters:

Chapter 1 presents the general information about uranium intermetallics (i.e. magnetism, magnetic phase diagram) as well as the motivation of the author's work (i.e. synthesis of the well-known but not properly studied selected uranium-based materials and completely new materials and studying their physical properties as a function of the external parameters (temperature (T), doping (x), high magnetic fields (H), high pressures (p)).

Chapter 2 focuses on the magnetism of selected systems belonging to the orthorhombic UTX group (of TiNiSi structure-type), i.e. the development of the magnetic and superconducting state in the U(Co,Ru)Ge system (based on the publication [P1] in the list of 18 publications), polarized neutron diffraction experiments on UCoGe ([P2]), the *T-x* and *H-x* phase diagrams in U(Co,Rh)Ge system ([P3]), *p-T* phase diagram ([P4]) and *T-H* phase diagram of UIrGe ([P5]), magnetism and phase diagram of U(Rh,Ir)Ge ([P6]) and U(Co,Ir)Ge ([P7]).

Chapter 3 concentrates on (U(Co,Rh)Al compounds belonging to the hexagonal UTX group (of ZrNiAl structure-type), such as magnetism and magnetic phase diagram of (U(Co,Rh)Al ([P8]), ferromagnetism in URhAl [P9].

Chapter 4 focuses on the synthesis and magnetism of newly discovered U_2Rh_2Pb compound, which reveals a strong magnetocrystalline anisotropy and exhibits a lowest critical magnetic field of the field-induced MT transition among U_2T_2X compounds ([P10]).

Chapter 5 presents the general trends of magnetism (itinerant ferromagnetism) in U-based compounds ([P11]), basing on an analysis the magnetic data of 69 uranium, 7 neptunium, and 4 plutonium.

Chapter 6 is a summary of author's contribution related to improvements of the single-crystal growth technique and facility for growing single crystals of new materials (in cooperation with others) and investigations of electronic and magnetic properties of $URhSi_3$ ([P12]), $UNi_4{}^{11}B$ ([P13]), the tricriticality in the H-T phase diagram of URhGe [P14] as well as growth of ω inclusions in Ti alloys and their investigations ([P15-18]).

Chapter 7 (Conclusion) is a short summary of the author's work presented in the habiliation thesis.

These 7 chapters are followed by biography (238 cited references) and list of 18 publications.

There are some editorial errors: 1) In the textbook, T_C: Curie temperature, T_c : superconducting temperature (not T_{SC}), 2) page 7 line 2 from bottom: "give rise to", 3) page 8, end of section 1.4: biography, list of author's work (list of publications) cannot be considered as a "chapter", 4) page 11: Figure 2.3 Panel (a) the $T_C - x$ phase diagram (instead of T - x), 5) page 29: no subsection (4.1) should be used. In other words, subsections are used only when the text is consisted of at least 2 or more subsections, page 34, section 6.2 and page 47, [P13]: $UNi_4{}^{11}B$. I would like to state here the list above is only related to the editorial aspect of the habilitation thesis. In my opinion, there are many abbreviations in the text (SOMPT, FOMPT, MCE, CPM, PPM…). It should be good to have the list of the full names and their abbreviations at the beginning of the habilitation thesis so that it give some good guide for the readers.

In summary, I would like to stress that the presented results presented in the habilitation thesis are new and valuable, and obtained on high-quality single crystals grown by the author. They bring an important contribution to our knowledge of physics of uranium-based compounds. In particular, it is worth emphasizing the publications that pushed the boundaries of knowledge of:

- evolution of ferromagnetism and quantum criticality in pseudoternary system $U(Co_{1-x}Ru_x)Ge$ [P1],
- b-axis metamagnetism in $U(Co_{1-x}Rh_x)Ge$ [P3],
- tricriticality in the antiferromagnet UIrGe with orthorhombic anisotropy [P5, P12],
- correlated paramagnetic regimes in UTGe compounds [P3, P5 - P7],
- critical behavior and spin fluctuations in itinerant f-electron ferromagnets [P9, P11].

As a summary, I would like to stress that the results presented in the habilitation thesis are new and valuable, especially all results were obtained on high-quality single crystals. They bring important contribution to our knowledge of phase diagram as well as electronic and magnetic properties of uranium-based compounds, in particular the pressure evolution of ferromagnetic ordering in these 5*f*-electrons of the UTX compounds.

The scientific level of the habilitation thesis is very high. Especially the obtained results have come from the scientific activity of RNDr. Jiří Pospíšil Ph.D. (e.g. realizing the research projects) as well as his fruitful cooperation with many research groups in foreign institutions.

Regards his overall scientific achievements, RNDr. Jiří Pospíšil Ph.D. was the author or co-author of 52 publications in the C1-list (v odborných časopisech vydávaných v zahraničí) plus 9 in the C3-list (v recenzovaných sbornícívh vydávaných v zahraničí). The number of citations is 360 citations (SCOPUS). The H-index is 11. He was the author of 11 oral contributions including 1 invited talk (in SCTE 2018, Austria, Wien) and more than 60 poster presentations in international conferences. He has also 2 invited lectures (in Karlsruhe Institute of Technology in 2013, in Technische Universität Bergakademie Freiberg in 2019).

He participated in 13 scientific projects (GARC (8), GAUK (2) and others), in which he was the project leader of 4 projects (GARC (2), GAUK (2)). By a part of his research work, the author significantly contributed to the development of single-crystal growth methods and instruments in the open access research infrastructure MGML (https://mgml.eu/) operated by DCMP FMP CUNI. During the period 2019-2022, he has contributed to the pedagogical work related to the new course “Preparation of single crystals for materials research”.

RNDr. Jiří Pospíšil Ph.D. is an experienced researcher, gaining good experiences through long-term stays in foreign scientific institutions (such as 5 months stay (2010/2011) in Neutron Scattering Group in National Institute for Materials Science (NIMS) in Tsukuba and 3 years- postdoc (2014-2017) in the Japan Atomic Energy Agency in Advance Scientific Research Centre, Tokai, Japan) and many short-term stays and visits in e.g. Germany, France. He has good scientific cooperation in France, Germany, Japan and carried out the investigations by means of many modern techniques, such as neutron diffraction, high magnetic field and high-pressure facilities, XMCD, ARPES, IXS.

In conclusion, the habilitation as well as the scientific achievements of RNDr. Jiří Pospíšil Ph.D fulfills the formal requirements of the Czech regulations concerning the habilitation theses. I recommend it for further proceeding of the habilitation procedure by the Faculty of Mathematics and Physics of Charles University in Prague.

I have passed the originality of the Turnitin system; it is clear that the work represents an original work with a single overlap into the existing author's literature. The (auto) plagiarism audit (Turnitin report) did not indicate a scientific error regarding copying.

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