Reviewer's report on doctoral thesis

U in metastable systems: structure, magnetism, superconductivity

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The thesis of Volodymir Buturlin deals with detailed and advanced physical characterisation of various stable and metastable binary uranium alloys and their hydrides synthesized by various methods. As such it is nicely fulfilling both part of the specialization - Physics of Condensed Matter and Materials Science (I guess that specialization name on the first page is just incomplete). The range of studied materials and used methods are staggering and if all materials and characterisation was done solely by the candidate, it has my respect. The range of materials spans of two binary alloys U-Ti and U-Nb prepared by arc melting and splat cooling and their hydrides. Dealing with many metastable alloys and the preparation of hydrides was apparently not easy task. Only mastering all these methods is a feat of its own. It is only pity that in the thesis there is no single list of prepared materials, which are studied. Summarizing all materials in one table would help in orientation for a reader of the thesis. I sorely miss such a listing. The prepared materials are then characterised by X-ray diffraction to identify the phase, by scanning electron microscopy (EBSD and EDS) to identify the phase distribution and then by battery of physical methods, transport and magnetic in broad range of temperatures and field. The thesis demonstrated impressive range of method mastered by the candidate. Again in itself this would merit the full thesis.

The thesis is divided unconventionally (and according me – unbalanced) to eight parts, from which five chapters are introduction to the field, chapter six is experimental, chapter seven brings the results and (much less) discussion followed by short conclusion and future outlook. It is followed by the list of candidate's publications and list of abbreviation. It would be nice to have for orientation in this complex work also the list of used symbols but it is missing.

In the Introduction the candidate really starts from the basic principles (formation of the magnetic moment) and building up toward strong electron correlation effects in U-based compounds. With the such broad span the simplification must occur and inconsistences arise which make the understanding sometimes difficult. Immediately, on the first page I would ask what is "strong magnetism"? And I guess that author did not "discover the problematics of the ordering...". I am not quite sure if this detailed description should be in the thesis and I believe

that the author should concentrate on facts directly connected to the research work and on the literature which motivates his own research. For instance, the author describes in some detail Hund's rules and then in subchapter 1.2.3. he wrote "In other words, Hund's rules are not helpful for the understanding of the atomic magnetic properties." Nothing more. Can respectable candidate explain why and when Hund's rules are invalid? And what means sentence "Binary U-T (T – transition element) intermetallics are paramagnets with moderately enhanced Sommerfeld coefficient γ, which reflects the density of states at the Fermi level, and the magnetic susceptibility $\chi(T)$."? What reflects the susceptibility? Similar mishaps are unfortunately occurring through the thesis.

The chapter four in the introduction deals with metastable U-compounds and their unconventional method of preparation (laser glazing not lazer) and the fifth with hydride formation of U-compounds. Here one would expect some actual results of U-based hydrides from literature which would build the bridge to the experimental work of the candidate. In summary more specific information related to the actual research would be nice.

The Experimental chapter seems to be long enough but considering the broad range of preparation and characterisation methods used, it feels short. Although the general principles of the methods are stated clearly it is a pity that more text is not devoted to specific types of measurements. Some of the description is then in results but I think that more could be described in Experimental section. And as I already mentioned the table of all prepared materials is missing. Here I have one question concerning magnetic measurement. I guess that magnetic moment was not measured by ACMS. What is difference between ACMS and VSM option in PPMS? Please, describe clearly the principles of measurements and differences. And one additional question why does ACT provide greater sensitivity compared to DC measurement?

The longest chapter is Results and Discussion. Unfortunately, there is much more results compared to somehow only limited discussion. The author piled impressive amount of many various results on many samples and compounds but unfortunately the data organization is not good and one feel that the experiments were done somehow randomly. I miss better description of the connection between collected experimental data obtained by different methods and also clear statements made from them to answer the question what new we learnt about physics of the material. Sometimes raw data are presented instead of evaluated and summarized results. In general, the evaluated results should be presented more in graphs not just in the text. This makes the interpretation difficult and sometimes incomprehensible. There are many interesting measurements listed and experimental facts obtained. However, as rather nonspecialist in the field, I cannot comment on the originality of the obtained results.

On the formal side, the thesis text is mostly free of errors, the misprints are not many sometimes as funny as "contract to" instead of "contrast to" or "reduction of the reduction". A

certain problem is occasional awkwardness of the language and sentence building. This, however, I expect will be improved in the time course of writing more papers and reports. I would like also point out that figure captions are often too concise and brief and due to that the figure cannot be understand on its own. The context in the text has to be searched and it is sometimes difficult as the figure is placed well away from the text referring to them. Tables are indicative but in Table 4 somehow the literature data are missing.

The list of candidate publication contains six impacted publications and impressive list of presentations. From all published papers two has the candidate as the first author. I just wonder that the last publication is from 2019 and there is no paper in 2020 which I would expected as the thesis is concluded and usually the publication is pursued.

Despite my criticism I valued the thesis highly. I expect the questions listed in the text to be answered. Based on the quality of the research described in the thesis I have no doubt about candidate ability to pursue scientific research. He only need to stop sometimes in frantic experimentation and considering what he is doing and think the things through.

I fully recommend that the presented thesis is accepted for awarding the PhD degree.

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