I. Tkach, PhD. Thesis, opinion of supervisor

The PhD thesis of Ilya Tkach, "Superconductivity and electronic properties of γ-U alloys and their hydrides", represents main results of the research of the candidate obtained in the period 2010-2015. Following his task to explore properties of nanostructured uranium systems he started to use systematically the technique of splat cooling to explore its potential in impeding the transformation from the high temperature *bcc* structure of Uranium and its alloys.

The *bcc* U alloys, which were discovered more than half century ago, have been so far material of significant technological importance (as nuclear fuels), but knowledge of their low temperature properties remained fragmentary. The finding of I. Tkach, that the rapid cooling can reduce the necessary concentration of alloying elements Mo or Zr, opened an avenue to their systematic research from the point of view of representation of true γ-U structure, which is thermodymanically stable only at high temperatures. The data revealed that the moderate volume expansion does leave unaffected magnetic susceptibility, while the Sommerfeld coefficient γ is almost twice enhanced with respect to pure (α) Uranium. The most interesting were results of the studies of superconducting properties. They corroborated the suggestion (made by US researchers recently) that the α-U superconductivity is not a true bulk effect, but the superconductivity of *bcc* U-Mo alloys is a robust bulk phenomenon with relatively very high upper critical field.

The apparent stability of the U splats in air led to the idea to explore the behaviour when exposed to hydrogen gas. Pure U metal reacts with hydrogen at low pressures already, producing fast a fine pyrophoric powder burning in a violent reaction in contact with oxygen. Quite remarkably the alloy splats did not form conventional UH_3, segregating the alloying metals. The splats did not react at all – at least at ambient pressure. Enhancing hydrogen pressure to 100 bar changed the situation, but the segregation still did not take place. The product was a hydride, but not powder–like, it was monolithic material stable in air, and X-ray diffraction indicated its amorphous nature. This was the first step to the discovery of a new class of materials, doped uranium hydrides, which can adopt either the conventional β-UH_3 structure, but more interestingly also amorphous, as nanogranular β-UH_3, or crystalline α-UH_3. Studies of these materials, which started a new direction of research, represent the second part of the thesis. Unlike weakly magnetic superconductors, the hydrides are exclusively strong ferromagnets, in which alloying even increases Uranium magnetic moments and Curie temperatures. Interesting findings include the recognition that the magnetic properties depend very little on type of structure, which contradicts to conventional understanding of Uranium magnetism.

The presented thesis collected numerous fundamental data, which became basis for a broader experimental and theoretical research and which stimulated utilization of advanced diagnostic methods, so far uncommon in the field of actinides, as Electron Back Scattered Diffraction, or transmission electron microscopy. Although I. Tkach was not performing such analyses himself, he was active in preparation of samples and discussing the results. In total he was therefore involved in many experimental techniques and types of problems from superconductivity to magnetism in nanosystems. He was lucky to work for a large part of his thesis on edge cutting problems, which required solving technical problems and unexpected situations. The results are reasonable well organized to provide a good record of experimental findings. Own experimental part is preceded by a brief theoretical introduction, worked out using unusually mostly own words and text styling. This reflects quite specific approach of I. Tkach to his research activities, in which he always tried to build step by step a personal relation to the studied materials. Perhaps that was the reason why he missed little bit a global view (which would help reader to understand facts easier) and did not want to go to far into

suggestions and speculations. In some cases he did not avoid common mistakes, as realistic assessments of real precision of parameters obtained from fits. This does not, however, degrade the value of the thesis, which should be accepted as a basis for awarding the PhD degree. At the end I would like to point out that large parts of the thesis have been already published in peer reviewed publications, partly as extended papers in most prominent journals in the field of condensed matter physics and nuclear technology. Several such papers based mostly on the data of I.T. are still in the stage of preparation, with the delay caused by our politics to have the conclusions corroborated by the advanced diagnostic (mentioned above), which became available only recently.

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