



Institute of Experimental Physics
Slovak Academy of Sciences

Watsonova 47, 040 01 Košice, SLOVAKIA
tel.: +421-55-7922201, fax: +421-55-6336292, e-mail: sekr@saske.sk



**Opponent report on the habilitation thesis of
RNDr. Jiří Prchal, Ph.D.**

Title of the habilitation thesis:

Pressure impact on physical behavior of intermetallics

The thesis presents a selection of studies on intermetallic compounds which were investigated under the influence of external pressure. Investigated was above all the influence of pressure on their structural and electronic properties.

Specifically deals the thesis with a) structural changes in magnetic materials, b) magnetism in rare-earth based tetragonal compounds and c) *pari-magnetism* in $R\text{Co}_2$ under pressure, and with d) pressure impact on the properties of U and Ce-based compounds. A part of the thesis is devoted also to high pressure techniques. The investigated systems as well as the methods of investigation under high pressure are highly topical.

In more detail, in part (a) an unexpected structural discontinuity / transition was observed in ternary rare-earth compounds crystallizing in hexagonal crystal structure. The observed experimental results were explained by total-energy calculations based on density-functional theory which revealed the occurrence of two energy minima that elucidate the isostructural transformation between two phases, with c/a values below and above the forbidden range. It was e.g. shown that TbNiAl represents a rare example of well localized systems in which the magnetic ground state is strongly influenced by external pressure.

Within part (b) an interesting investigation was performed on YbAu_2Si_2 , in which ytterbium atoms can lead to unusual behaviour including the change of valence, non-integer valence or valence fluctuations, as possible origins of unconventional critical phenomena. However, just a non-magnetic Yb^{2+} valence state could be derived from various measurements in external pressures up to 3.2 GPa.

In part (c) the family of Laves-phase $R\text{Co}_2$ compounds (R = rare-earth element) in which magnetism originates from two different magnetic sublattices, was studied. The interest into these compounds was motivated by the discovery of a peculiar phenomenon of short-range magnetic order in the paramagnetic state denoted as "*pari-magnetism*". The pressure development of this phenomenon was studied on HoCo_2 , in which the corresponding Ho and Co magnetic ferromagnetic sublattices order ferrimagnetically below about 79.5 K. It was shown that in the *pari-magnetic* region Co moments form ferromagnetic clusters which have a short-range antiparallel configuration with the nearest Ho moments up to a flipping temperature of about 125 K.



Institute of Experimental Physics
Slovak Academy of Sciences

Watsonova 47, 040 01 Košice, SLOVAKIA
tel.: +421-55-7922201, fax: +421-55-6336292, e-mail: sekr@saske.sk



In part (d) e.g., using a Bridgman anvil pressure cell, investigations on single crystalline UPd₃ up to 10 GPa were performed - testing a possible delocalization of 5f - electrons due to lattice compression.

In the part devoted to high pressure technique the characterization of a new pressure medium Daphne Oil 7575 down to low temperatures is presented.

Thus, the habilitation thesis contains a lot of original and very interesting results which are more in detail described in the comments and summary of results, as well as in attached publications. The high level of these results is documented by relevant high-quality publications in CC journals (some of them in journals with a high impact factor) and by a considerable number of responses (citations) to the obtained results. And, the development and use of high-pressure technology during all investigations of intermetallic compounds seem to define clearly the research program of Dr. Prchal - study of materials under extreme conditions.

The habilitation thesis itself is written clearly, in good English and with a good graphic design. As regards the certain overlap in the control of originality done by system Turnitin, it apparently comes from the fact that the thesis includes besides the text (comments of results) also a set of papers the author or co-author of which is Dr. Prchal.

Since practically all scientific results of the habilitation thesis (the related publications) have been appropriately reviewed in corresponding journals, it probably does not make sense to comment them in a critical way.

The questions I would like to ask Dr. Prchal are therefore as follows:

- could he (illustratively / more in detail) explain the notion "paramagnetism", the state between para-magnetism and ferri-magnetism in RCo₂ compounds, and describe how this state depends on temperature and magnetic field?
- what are his next plans in the development of high-pressure technology and for which physical systems (materials) he would like to use it?

In conclusion I would like to state that the results obtained in the habilitation thesis are at high level and I consider them as a significant contribution in the study of intermetallics in extreme conditions, especially under the influence of high pressure. Thus, the submitted thesis and the achieved scientific results, in my opinion, clearly meet all the requirements imposed on the habilitation procedure. Therefore, I recommend to appoint RNDr. Jiří Prchal, Ph.D. as associate professor.

Košice, October 6, 2021


assoc. prof. Dr. Karol Flachbart, D.Sc.