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Review of the dissertation thesis of **Mgr. Daniel Staško**

Crystallographic and electronic properties of rare-earth $A_2B_2\mathrm{O}_7$ oxides under extreme conditions

I first met Daniel Staško in 2018, when he began his master's studies under my supervision. His master's thesis focused on the magnetic and transport properties of selected intermetallic compounds under hydrostatic pressure. After completing his thesis, Daniel transitioned into Ph.D. studies in 2020, shifting his focus – alongside me – to the fascinating field of rare-earth-based $A_2\mathrm{Ir}_2\mathrm{O}_7$ pyrochlore oxides. These materials, renowned for their intricate structural, electronic, and magnetic properties, provide a wealth of challenges and opportunities for exploration.

Daniel's doctoral research has focused on the structural, magnetic, and electron transport properties of $A_2\mathrm{Ir}_2\mathrm{O}_7$ iridates under extreme conditions such as low temperatures, high magnetic fields, and especially high external pressures. His work combines experimental rigour with theoretical insight, with a particular focus on the heavy rare-earth members of the series (*A* = Dy – Lu), which have been relatively understudied compared to their lighter counterparts.

A key achievement of Daniel's research lies in the successful synthesis and especially the characterization of these materials in both polycrystalline and single-crystal forms. Through advanced techniques of synchrotron X-ray scattering, he has confirmed the stability of the pyrochlore lattice across the entire rare-earth series at temperatures down to 4 K and pressures up to 20 GPa. His detailed analysis of compressibility and local structural distortions enhances our understanding of these materials and offers valuable frameworks for future studies in the field of pyrochlore iridates and related compounds.

Daniel has also contributed significantly to understanding these materials' semiconductor-insulator transition. This transition was concluded to be driven by the all-in-all-out (AIAO) antiferromagnetic ordering of the Ir sublattice, reflecting a delicate interplay of electronic and magnetic interactions in pyrochlore iridates. In addition, his work shows how applying high external pressure shifts this transition to higher temperatures, a finding that underscores the tunable nature of these materials. Magnetoresistivity studies of $Lu_2Ir_2O_7$, for instance, revealed a linear asymmetric contribution influenced by cooling fields, which grows under pressure and is linked to the dynamics of antiferromagnetic domain structures.

In parallel, Daniel's magnetic studies have uncovered a subtle yet robust ferromagnetic signal within the antiferromagnetic phase of $Er_2Ir_2O_7$ and $Lu_2Ir_2O_7$ single crystals. Using a domain wall model, he attributes this phenomenon to ferromagnetic contributions at antiferromagnetic domain interfaces. This work enriches our understanding of magnetic domain behaviour and suggests intriguing applications in spintronics. His calculations reveal that the antiferromagnetic domains in $Lu_2Ir_2O_7$ are significantly smaller than those in related compounds, such as Nd and Eu pyrochlores, hinting at unique structural and magnetic dynamics within the heavy rare-earth part of the iridium series.

Daniel's dissertation thesis is structured to provide both depth and clarity. It consists of (i) the theoretical background reviewing geometrically frustrated materials, their electron and magnetic properties, metal-insulator transitions, and impact of external pressure; (ii) the experimental part with a detailed description of advanced experimental techniques, including synchrotron X-ray diffraction, electrical resistivity, and magnetic properties measurements and high-pressure methods; (iii) the contextual review summarizing prior studies on $A_2B_2O_7$ oxides, emphasizing the context and relevance of his work; (iv) the main results of the work, ranging from structural stability and transport properties to magnetic domain modelling; (v) key findings of the work are discussed in the fifth part of the thesis, together with prospects for future investigations of related materials; (vi) a summary of most important findings concludes the dissertation thesis.

Daniel's findings related to the thesis have been disseminated through eight peer-reviewed articles, which are already making an impact in the field. He is an author and co-author of a total of 13 publications. His expertise in designing and conducting sophisticated experiments and his growing mastery of advanced techniques position him as a promising researcher in condensed matter physics.

In summary, Daniel Staško's work on rare-earth pyrochlore iridates contributes valuable insights into the intricate interplay of structure, magnetism, and electronic transport in these materials. His dedication, methodological rigour, and ability to tackle complex scientific questions make him a significant asset to the research community. Therefore, I recommend awarding Daniel Staško a title PhD.

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