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Review report on the doctoral dissertation of Anna Abramuk:

"Properties of exotic nuclei with a high excess of neutrons in the mass region A = 110"

The dissertation reports on new results concerning the structure of neutron-rich nuclei ^{107}Mo, ^{117}Ag and ^{119}Ag. The nuclei were studied via beta decays of ^{107}Nb, ^{117}Pd and ^{119}Pd at the Ion Guide Isotope Separator On-Line (IGISOL) facility in the JYFL Accelerator Laboratory. Thanks to the JYFLTRAP double Penning trap mass spectrometer, monoisotopic samples of ^{107}Nb, ^{117}Rh and ^{119}Pd were implanted into a movable tape surrounded by a plastic scintillator for beta particles and three Low-Energy Ge detectors (LeGe) for gamma rays. The results have already been published in three peer-reviewed scientific articles in Physical Review C, which is a high-quality journal in the field of nuclear physics. Anna Abramuk is listed as the first author in the ^{117}Ag paper from 2025, as a second author in the ^{119}Ag paper from 2022 and as a fourth author in the ^{107}Mo paper from 2019. Therefore, her role has been essential in the published articles. However, her contributions (e.g. data analysis, interpretation, writing) to the articles could have been spelled out with a couple of sentences in the end of Chapter 1.

The thesis is structured in nine chapters and an appendix. It starts with a short introductory section outlining the scope of the work. It is followed by motivation and research questions. The main questions the research aims to address are: 1) Are there isomeric states in the studied nuclei and what determines their existence? 2) What kind of deformations are observed in the studied nuclei? 3) What kind of new phenomena in nuclear structure of neutron-rich nuclei can be found? 4) What kind of trends, or their rapid changes, can be deduced from the systematics of the studied nuclei in the A=110 region? 5) Will the nuclear spectroscopy yield consistent results with the optical spectroscopy? In addition to nuclear structure, the astrophysical relevance in the context of the rapid neutron capture process is briefly discussed in Chapter 2.

The author presents the general theoretical knowledge in nuclear physics in Chapter 3 "Theoretical Background". It covers a broad range of topics in nuclear physics relevant for the thesis. Here, also more modern models than the liquid drop and the shell model could have been shortly introduced as later those will be used in the interpretation of the results, e.g. FRDM/FRLDM macroscopic–microscopic model (refs. 116 and 118) and relativistic mean-field framework of ref. 117.

Chapter 4 covers the experimental methods and describes the used setup. The spectroscopic techniques used for the analysis of the collected data are further described in Chapter 5. While Chapter 5 shows that the author masters the spectroscopic techniques, there are some deficiencies in the production of the isotopes part in Chapter 4. For example, the general ISOL method is

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mixed with the more specific IGISOL technique giving the impression that all ISOL facilities would use helium or argon gas for thermalizing the products. This is not true at most of the ISOL facilities, which typically employ thick targets and separate ion sources for ionization. Moreover, there are some deficiencies in the use of references in this experimental section. For example, ref. 67 describes the JYFLTRAP Penning trap and does not discuss the thermalization into 1+ charge states but it is used for a reference for that. The sentence "Approximately 99% of the ions hit the target shield and are lost at this stage [65]." is not found in Ref. 65 and is questionable. Figure 13 cannot be found from Ref. [68] and it does not describe the fission ion guide but the light ion guide. The fission ion guide looks different as can be seen from Fig. 1 of Ref. [68]. Not all ions are singly charged, although they usually constitute the main fraction of the ions. Figure 14 shows the IGISOL facility as it used to be before 2010 in the old target hall. The new facility, which was employed for the experiments described in the thesis, is shown, e.g., in Fig. 1 of Z. Ge et al. Phys. Rev. C 103 (2021) 065502 or Fig. 1 of H. Penttilä et al., EPJ Web of Conferences 239, 17002 (2020).

Chapters 6, 7 and 8 present the results regarding the beta-decays of ^{107}Nb, ^{117}Pd and ^{119}Pd, respectively. The results have already been published in the three peer-reviewed, published articles. For ^{107}Mo, around ten new excited levels were found and altogether 28 gamma-ray transitions were measured. The $5/2^+$ state was found to be an isomeric state at 65.4 keV and not the ground state of ^{107}Mo. The half-life measurement for ^{107}Nb is also reported in the original publication Phys. Rev. C 100, 034316 (2019) but not described in the thesis although it is mentioned in the conclusions. In the beta decay of ^{117}Pd, altogether 15 new levels and 17 new gamma-ray transitions were observed. A weakly deformed band built on the $1/2^-$ ground state of ^{117}Ag was observed for the first time suggesting shape coexistence. For the beta decay of ^{119}Pd, an important finding is that the ground state of ^{119}Ag is shown to be $1/2^-$ and the previously considered $7/2^+$ ground state is an isomer at 33.4 keV. The beta-decay scheme of ^{119}Pd was substantially extended, including more than 30 excited levels and altogether 63 gamma-ray transitions assigned to ^{119}Ag. The half-life was also determined for ^{119}Pd, however, in some places like on page 108, it is mentioned as the "half-life of ^{119}Ag", which should be corrected. The beta-strengths for the observed transitions have also been deduced for the beta decays of ^{117,119}Pd.

The historical overview sections 6.6, 7.9 and 8.8 are given after the results, while it might have been more beneficial to know the status before the results of this work, and then the author could have immediately discuss how the new results relate to the earlier knowledge of the topic. The sections 6.7, 7.10, and 8.9 would have benefitted from tables or graphs summarizing the contents and making the comparisons easier. Now the different predictions and models are often listed one after another leaving the conclusions somewhat superficial. The FRDM and FRDML model frameworks could have been better explained in the theory background chapter of in 7.10. These models also have predictions for odd-mass nuclei, they are not limited to even-even nuclei.

Chapter 9 summarizes the results and conclusions for each studied nuclide. It is followed by an appendix A, which is a kind of an outlook what could be done in the future. The thesis could benefit from combining Chapter 9 with the shortened contents of the appendix, into a new "9. Conclusions and Outlook" chapter. Regarding the methods, it should be better clarified what can be measured with optical spectroscopy and what with mass spectrometry. Now these are somewhat mixed in the Appendix chapter.

All in all, the dissertation shows that the doctoral candidate has the relevant theoretical knowledge on the topic and can independently carry out scientific work. The methodology regarding the spectroscopy is well described. The conducted research has provided new information on the structure of neutron-rich nuclei in the A=110 region, with several new levels and gamma-ray transitions discovered, and level schemes substantially extended. Key new information on the isomeric states in the studied nuclei was also obtained. The results are

discussed in the context of nuclear structure and help to understand the shapes and shape coexistence in this region. The systematics of the studied molybdenum and silver isotopes were further extended. As such, the dissertation presents a significant contribution to the knowledge of nuclear structure in this region and provides original solutions to the research questions outlined in the work.

In conclusion, the dissertation manuscript meets the criteria for a PhD thesis. There are some issues that could be corrected before the final publication of the thesis as pointed out above. There are also minor stylistic things that could be fixed throughout the thesis. For example, there are many one-sentence paragraphs, sentences starting with "And.." and sometimes references are missing. For these, I will electronically provide an annotated pdf for reference.

Yours sincerely,

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