論文審査の結果の要旨

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Taniuchi-san's thesis entitled " In-beam gamma-ray spectroscopy of ^{78}Ni" consists of 7 chapters. After the introduction, chapter 2 describes the principle of the experiment and chapter 3 the experimental setup. The data analysis is detailed in chapter 4. Results for the in-beam gamma-ray spectroscopy of ^{78}Ni presented in chapter 5 are discussed in comparison with various theoretical models in chapter 6. Chapter 7 is the conclusion and outlook to future studies.

The objective of the thesis was to study excited states in ^{78}Ni for the first time, and thus get indirect confirmation of the shell closures at proton number Z=28 and neutron number N=50. The experiment was performed as part of a large international collaboration, and the spokespersons of said collaboration have agreed that Taniuchi-san writes his doctoral thesis about a part of the experimental program. Tanuichi-san's own contribution to the project are the data analysis of the most prominent reaction channels, the one-proton removal reaction from ^{79}Cu and the two-proton removal from ^{80}Zn.

The physics interest in ^{78}Ni is large as this is the heaviest doubly-magic neutron-rich nucleus that can be produced at present date radioactive beam facilities. The excitation energy of the first excited state is predicted to be large, as a result of the two shell closures. Radioactive beams of ^{79}Cu and ^{80}Zn have been produced by means of projectile fragmentation at the RIBF, RIKEN Nishina Center. The BigRIPS fragment separator was used to separate and identify beam particles event-by-event.

The beam impinged then on a 10 cm long liquid hydrogen target, surrounded by a time-projection-chamber (MINOS) for proton detection and vertex reconstruction, as well as the NaI(Tl) array DALI2 to measure the γ-rays emitted from excited states.

Taniuchi-san's contribution to the study is mainly the offline data analysis. He follows the standard analysis procedure for BigRIPS and ZeroDegree to obtain the particle identification and inclusive cross sections. Doppler correction using the vertex reconstruction of MINOS and add-back of hits in neighboring DALI2 crystals allow for the first spectroscopy of ^{78}Ni, a major achievement in nuclear structure physics. The high excitation energy of the first 2^+ state of 2.6 MeV points to the fact that ^{78}Ni is a doubly magic nucleus. In the neighboring less exotic Ni isotopes this state is located at about 1 MeV. Candidates for other transitions are also observed. For each transition and each of the two reaction settings, a statistical analysis of the significance of the transition is performed. In the two proton removal reaction a candidate for a 2.9 MeV state, possibly the second 2^+ state, is found. Spin and parity assignments are not possible in this work, and are only done in comparison with theoretical calculations and the systematics of Ni isotopes. The data are compared with various theoretical calculations, mostly large scale shell model calculations performed by Taniuchi-san's collaborators. These calculations predict the occurrence of shape coexistence if the model space used is large enough, meaning that many particle-hole excitation configurations are possible, resulting in a deformed excited band. Tanuichi-san also presents the exclusive cross sections for several proposed final states in ^{78}Ni. The majority of the cross sections leads to direct population of the ground state through knockout of the $f_{5/2}$ valence proton, while the strength of the $f_{7/2}$ orbital, populated in knockout from the core, is not observed. In the shell model calculations it lies above the neutron separation energy.

In the last chapter a summary and an outlook to potential future experiments is presented. Further measurements could clarify the existence of the candidate states in ^{78}Ni, and also obtain more direct evidence for the magicity of ^{78}Ni. Shape coexistence is inferred in the present work only from the theoretical calculations, more detailed experiments are suggested.

In summary, the experiment was involving the, at that time, newly developed MINOS liquid hydrogen target, and the standard in-beam γ-ray spectroscopy setup at RIBF. Only with the high intensity beam of RIBF and the thick target, it was possible to reach the luminosity required for the first spectroscopy of the very exotic doubly-magic nucleus ^{78}Ni. The experiment is a tour de force, the analysis is sound, but not innovative. Given the limited statistics, assignments unfortunately remain tentatively.

したがって、本論文は博士（理学）の学位を授与できると認める。