Shell-model evaluation of beta-decay half-lives for $N = 50$ neutron deficient nuclei

M. Honma,[*1] T. Otsuka,[*2,*3,*4] T. Mizusaki,[*5] Y. Utsuno,[*6,*3] N. Shimizu,[*3] and M. Hjorth-Jensen[*4,*7,*8]

An accurate description of the structure of unstable nuclei has been one of the most challenging goals in theoretical nuclear physics. A precise prediction of various properties such as binding energies and transition strengths is important as an input of astrophysical simulations especially for nuclei that are beyond the current experimental reach. The doubly-magic nucleus ^{100}Sn is one of the key nuclei for exploring the proton-rich extreme, and various theoretical as well as experimental approaches have been made. In the previous report[1)] we presented the results of shell-model calculations for the Gamow-Teller transition strength distribution from ^{100}Sn. In this report, using the same framework, the β-decay half-lives are evaluated for several proton-rich N=50 nuclei.

As described in,[2)] the adopted model space consists of four single-particle orbits $1p_{1/2}$, $0g_{9/2}$, $1d_{5/2}$ and $0g_{7/2}$ for both protons and neutrons. Because of the computational limitations, we need to employ a suitable truncation scheme. In the present calculation, at most five particles are allowed to excite across the N or Z=50 shell gap relative to the naive filling configurations. The effective interaction was determined in a semi-empirical way. The starting Hamiltonian is derived microscopically[3)] based on the realistic N^{3}LO interaction,[4)] and it is modified by iterative fits to the experimental energy data. For the purpose of the lifetime evaluation, we need to know the Q-value, but it is not necessarily known experimentally. To test the reliability of the present scheme, the Q-values are also evaluated theoretically. The β^+-decay + electron capture processes through the Gamow-Teller transitions are taken into account. The standard quenching factor 0.74 is used for the transition operator.

As shown in Fig.1, the shell-model results basically follow the trends of the available experimental data for both Q-values and the half-lives. However, a systematic deviation can be seen. The half-life is underestimated for $Z \leq 47$ and overestimated for $Z \geq 48$. A part of this deviation is due to the inaccurate estimation of the Q-values, but even if the experimental values are used, there still remain some discrepancies. Probably this problem can be attributed to the insufficiency of the model space. In the present calculations, the possibly dominating transition $\pi g_{9/2} \rightarrow \nu g_{7/2}$ is fully taken into account, but some components such as $\pi d_{5/2} \rightarrow \nu d_{3/2}$ are excluded, that are anticipated to contribute to the states with higher excitation energies. The more proton-rich, the larger the Q-value window, and such components may have larger contribution. More extensive calculation is necessary to confirm this interpretation and improve the description.

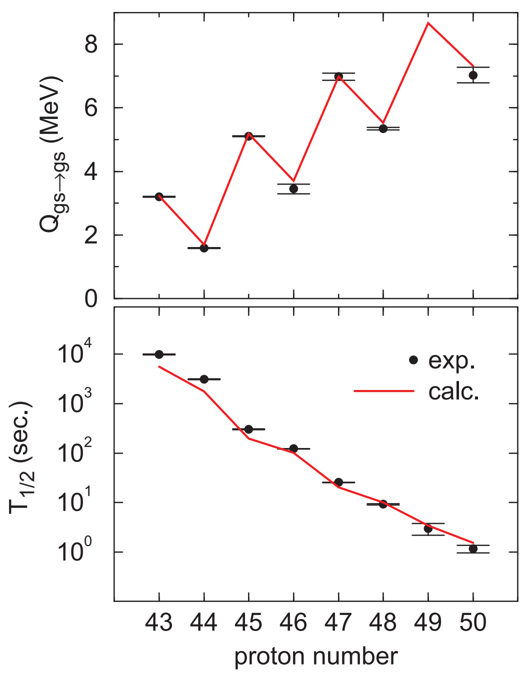

Fig. 1. Comparison of (upper panel) Q-values ($Q_{\mathrm{gs}\rightarrow\mathrm{gs}}$) and (lower panel) half-lives ($T_{1/2}$) between the experimental data (symbols) and the shell-model results (lines) for $N = 50$ nuclei with $43 \leq Z \leq 50$. Experimental data are taken from Ref.[5)] The shell-model results are obtained by using the efficient shell-model code MSHELL64.[6)]

*1 Center for Mathematical Sciences, University of Aizu
*2 Department of Physics, University of Tokyo
*3 Center for Nuclear Study, University of Tokyo
*4 National Superconducting Cyclotron Laboratory, Michigan State University
*5 Institute of Natural Sciences, Senshu University
*6 Advanced Science Research Center, Japan Atomic Energy Agency
*7 Department of Physics and Astronomy, Michigan State University
*8 Department of Physics, University of Oslo

References

1) M. Honma *et al.*, RIKEN Accel. Prog. Rep. **48**, 89 (2015).
2) M. Honma *et al.*, RIKEN Accel. Prog. Rep. **47**, 64 (2014).
3) M. Hjorth-Jensen *et al.*, Phys. Rep. **261**, 125 (1995).
4) D. R. Entem *et al.*, Phys. Rev. C **68**, 041001(R) (2003).
5) Data extracted using the NNDC WorldWideWeb site from the ENSDF database.
6) T. Mizusaki *et al.*, MSHELL64 code (unpublished).