Triaxial dynamics in low-lying states of ^{44}S and ^{46}S†

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Neutron-rich nuclei around $N = 28$ have garnered considerable interest recently. In ^{43,44}S, the breaking of $N = 28$ magicity and shape fluctuations were predicted[1–3] on the basis of the analysis of the potential energy surface (PES) in quadrupole deformation parameters β and γ and low-lying spectra using the generator coordinate method. We investigated low-energy dynamics governed by triaxial deformation in neutron-rich $N \approx 28$ nuclei (^{44}S and ^{46}S) using the five-dimensional quadrupole collective Hamiltonian method. Moreover, we focused on the role of collective mass functions in kinetic energies of the collective Hamiltonian.

We calculated the collective potential using the constrained Hartree-Fock-Bogoliubov method with the SkM* Skyrme energy-density functional (EDF) and the collective mass using the cranking approximation with the SkM* EDF in the β-γ plane to construct the quadrupole collective Hamiltonian. By quantizing the collective Hamiltonian, we solved the collective Schrödinger equation to obtain excitation energies and collective wave functions for each state. Figure 1 illustrates the PESs of ^{44}S and ^{46}S in the β-γ plane. The PESs exhibit a flat behavior within the range of $0 \leq \beta \leq 0.25$ and along the γ direction, namely γ soft.

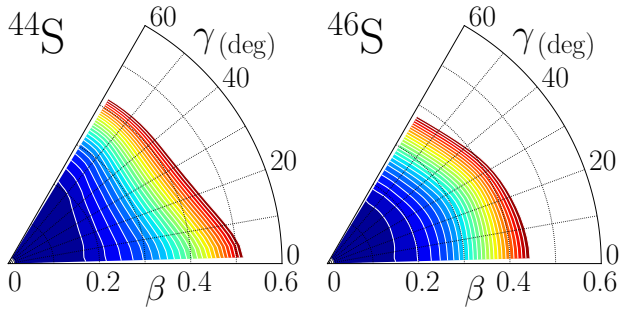

Fig. 1. PESs of ^{44}S and ^{46}S in the β-γ plane.

Although the PESs are similar, the low-lying excitation spectra of ^{44}S and ^{46}S are different. This difference originates from the collective mass. Figure 2(a) illustrates the energy ratios defined as $R_{0/2} = E(0_2^+)/E(2_1^+)$, $R_{2/2} = E(2_2^+)/E(2_1^+)$, and $R_{4/2} = E(4_1^+)/E(2_1^+)$ for several nuclei. In the light nuclei, the $R_{0/2}$ value mainly depends on the nucleus. This

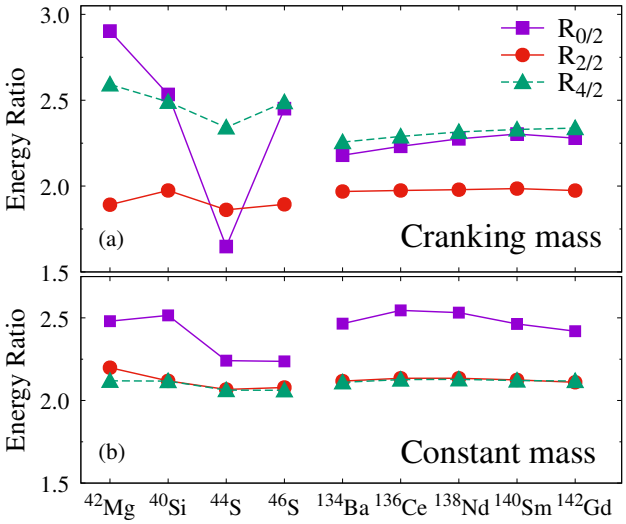

Fig. 2. Energy ratios, $R_{0/2}$ (filled square), $R_{2/2}$ (filled circle), and $R_{4/2}$ (filled triangle), of different nuclei obtained considering the cranking mass (a) and constant mass (b).

dependence originates from the collective mass because the variation in $R_{0/2}$ obtained with the constant mass is considerably small (Fig. 2(b)). Here, the constant mass indicates replacing the cranking mass with a constant value that ignores the β-γ dependence. Figure 2 illustrates the energy ratios in neutron-deficient $N = 78$ nuclei (^{134}Ba-^{142}Gd), whose PESs exhibit a topography similar to the one of ^{44,46}S. For both cranking mass and constant mass, the $R_{0/2}$, $R_{2/2}$, and $R_{4/2}$ does not exhibit a nucleus dependence. The strong nucleus dependence of $R_{0/2}$ is a unique property in neutron-rich $N \approx 28$ nuclei. Thus, we clarified the unique role of the collective mass in neutron-rich $N \approx 28$ nuclei. The ratios obtained from the available experimental data are $R_{4/2} = 1.86$, $R_{2/2} = 1.63$, and $R_{0/2} = 1.03$ in ^{44}S.[4] The $R_{0/2}$ value in the cranking mass exhibits a sudden drop in ^{44}S, although the experimental value is lower than the calculated one. More experimental data on the low-lying 0^+ state will provide insights into the role of the collective mass.

References

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