Role of deformation in odd-even staggering in reaction cross sections for ^{30,31,32}Ne and ^{36,37,38}Mg isotopes†

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We discuss the role of the pairing anti-halo effect in the observed odd-even staggering in reaction cross sections for ^{30,31,32}Ne and ^{36,37,38}Mg isotopes by taking into account the ground state deformation of these nuclei. We construct the ground state density for the ^{30,31}Ne and ^{36,37}Mg nuclei based on a deformed Woods-Saxon potential, while for the ^{32}Ne and ^{38}Mg nuclei we also take into account the pairing correlation using the Hartree-Fock-Bogoliubov (HFB) method.

We consider the collision of a deformed projectile nucleus with a spherical target nucleus and compute the reaction cross sections, σ_R. To this end, we employ the Glauber theory, which is based on the eikonal approximation and the adiabatic approximation to the rotational motion of a deformed nucleus. That is, we first fix the orientation angle of the deformed nucleus and then take an average of the resultant cross section over all the orientation angles:[1)]

$$\sigma_R = \frac{1}{4\pi}\int d\mathbf{\Omega}\, \sigma_{\mathbf{R}}(\mathbf{\Omega}), \tag{1}$$

where $\mathbf{\Omega}$ is the angle of the symmetric axis of the deformed nucleus in the laboratory frame, and $\sigma_R(\mathbf{\Omega})$ is the reaction cross section for a fixed $\mathbf{\Omega}$.

We analyze the experimental data at an incident energy $E = 240$ MeV/nucleon with a ^{12}C target. We use the same density for ^{12}C as that given in Ref. 2), while we use the same parameters given in Ref. 3) for the profile function, Γ_{NN} in the Glauber model calculations.

The reaction cross sections for the ^{30,31,32}Ne nuclei evaluated at $S_n(^{31}\text{Ne}) = 0.3$ MeV are shown in Fig. 1, along with a comparison to the experimental interaction cross sections.[4)] We also show the result of a previous analysis based on the spherical density distributions at a similar one neutron separation energy.[5)] One can see that the odd-even staggering can still be reproduced by taking into account the nuclear deformation. Notice that the degree of the staggering is lower in the present calculation compared to the previous spherical calculation because the valence neutron in ^{31}Ne fully occupies the $1p_{3/2}$ level in the spherical case, while the occupation probability for the $p_{3/2}$ level decreases from unity in the deformed case. We also checked the effect of pairing correlations on the odd-even staggering with the deformed wave functions. We found that the reaction cross section for ^{32}Ne is not sensitive to the value of the average pairing gap as long as it is large enough.

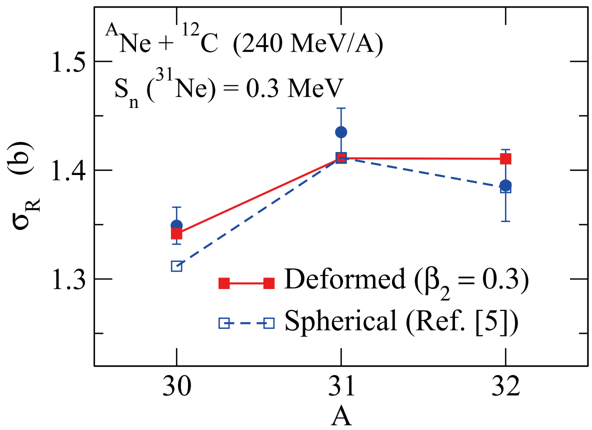

Fig. 1. Reaction cross sections for the ^{30,31,32}Ne + ^{12}C reaction at $E = 240$ MeV/nucleon evaluated at the one neutron separation energy of ^{31}Ne of $S_n = 0.3$ MeV. The filled circles with error bars indicate the experimental interaction cross sections taken from Ref. 4). For comparison, the result of the previous analysis in Ref. 5) based on the spherical density distributions is also shown by the dashed line.

We have also investigated the role of nuclear deformation in the odd-even staggering observed in reaction cross sections for Mg isotopes. We have shown that the deformation mainly decreases the degree of odd-even staggering, as in the Ne isotopes, because of the admixture of several angular momentum states in a deformed single-particle wave function. Despite this, the odd-even staggering persists even with finite deformation when the one neutron separation energy is small enough. These results strongly indicate that the pairing anti-halo effect indeed contributes to the observed odd-even staggering in reaction cross sections.

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