Isospin character of the first quadrupole transition in the A~100 region

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Through the selection of a hadronic projectile at a convenient bombarding energy, considering the Coulomb barrier of the mass region under study, it is possible to gather simultaneously information on the response of the nuclear system under both, the nuclear and electromagnetic interactions. The São Paulo Nuclear Spectroscopy with Light Ions Group has developed a method for a systematic analysis of the Coulomb-Nuclear Interference (CNI)[(1)] in the inelastic scattering of isoscalarly interacting projectiles by nuclei. This method is suitable for obtaining reliable information, especially for a comparative evaluation of the relative contributions of protons and neutrons to the first quadrupole excitation. The A ~ 100 mass region, where the important role played by the neutrons is recognized, constitutes an interesting field of investigation, since the usual assumption of dominance of simple collective effects is certainly not indicated. In this region, alpha particles and, in particular, deuterons were taken as convenient isoscalar projectiles, considering the bombarding energies suitable for the operation of the S. Paulo Pelletron accelerator. The inelastic scattering is described through the Distorted Wave Born Approximation (DWBA) formalism and the nuclear transition potential is treated as given by the deformed optical model potential (DOMP). To maintain free parameters under control, it is of utmost importance to choose global optical potential parameters. Through this macroscopic CNI analysis, the square of the mass deformation length, $\left(\delta_L^N\right)^2$, is extracted as a scale factor from the fit of the predicted cross sections to the experimental data and, analyzing the characteristic changes in the angular distribution shape, the value of the ratio between charge $\left(\delta_L^C\right)$ and mass $\left(\delta_L^N\right)$ deformation lengths, C, is also obtained. These quantities can be put in correspondence with the value of the isoscalar reduced transition probability B(ISL) and with the ratio B(EL)/B(ISL), respectively. The CNI was investigated through excitation function data focusing on the chain of the Ru isotopes to examine the collectivity of the first quadrupole excitation in the ^{100,102,104}Ru nuclei[(2)]. The values of δ_2^C/δ_2^N indicate a decrease of the effective contribution of the neutrons, when compared to the protons, when one and two pairs of neutrons are added to ^{100}Ru, for which C_2 is approximately one. On the other hand, agreement with the results of Coulomb excitation studies was obtained for the δ_2^C values. The interest in investigating the evolution of the collectivity also in the odd Ru isotopes was reinforced by the experimental diagnosis of possible shape coexistence at low energies[(3)] and by difficulties in the theoretical description of these nuclei. One of the intrinsic difficulties of the inelastic scattering studies in odd-even nuclei is the dilution of the collective degrees of freedom of the nuclear system among many states. Therefore, the total transition probability associated with the low energy excitations, with the multipolarity L of interest, which is normally concentrated in one or a few states in the even-even nuclei, is fractioned into 2L+1 or more states in the neighbouring nuclei. The present contribution refers to CNI measurements with deuterons on ^{99,101}Ru, the only odd stable isotopes in the Ru chain. The targets were both isotopically enriched to 95.5%, with thicknesses of ~10μg/cm^2. The inelastic scattering angular distributions, with 13 MeV incident deuterons, were obtained at the Pelletron Accelerator-Enge Magnetic Spectrograph facility in S. Paulo, using nuclear emulsion plates on the focal plane. Spectra associated with fourteen and sixteen scattering angles were measured for ^{99}Ru and ^{101}Ru, respectively, achieving an excellent energy resolution of ~8 keV and a good characterization of the interference minimum, which corresponds to the first quadrupole excitation of the cores. Values for δ_2^N and $C_2 = \delta_2^C/\delta_2^N$ were extracted by fitting the predictions to the experimental angular distributions through χ^2 minimization, using the iterative Gauss-Marquart method. The experimental values of C_2 of the states observed are larger than 1.2 in ^{99}Ru and than 1.3 in ^{101}Ru, pointing in the odd isotopes to an even more accentuated decrease of the neutron contribution relative to that of the protons, as a neutron pair is added. The results show that the admixture of particle degrees of freedom to the collective core modes in ^{99,101}Ru are not sufficient to destroy the characteristics of the L = 2 transfer to the low energy states of the odd nuclei. However, taking the correct statistical weights into account, the mass deformation lengths obtained do not reproduce perfectly the deformation of the core, tending to be smaller.

References

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