SCIENTIFIC REPORT

Contract no. 42TE/08.01.2025

Stage no. 1/2025

Gamma spectroscopy studies of the evolution of intruder configurations near the N=20 'inversion island'

The main objective of Stage no. 1/2025 was the experimental investigation of the 0^+ excited states of in the ^{32}Si nucleus and the preparation of the experiment dedicated to the study of the nucleus ^{38}S, using the ROSPHERE experimental arrangement within the 9MV Tandem Accelerator of IFIN-HH. The scientific motivation is given by the need to validate modern shell-model calculations, capable of describing the coexistence of "normal" spherical configurations with "intruding" deformed ones, generated by neutron excitations over the closure between the *sd* and *pf* shells. The ^{32}Si and ^{38}S nuclei, located at the border of this island of inversion, are ideal cases for testing the competition between the two types of configurations.

The major achievement of the first phase of the project is the determination of the spin and the experimental measurement, for the first time, of the half-life of the intruder state 0_3^+ (5788 keV) of ^{32}Si. Using the 2-neutron transfer reaction ^{30}Si(^{18}O,^{16}O)^{32}Si at energies below the Coulomb barrier (26 MeV) and the ROSPHERE setup, a value of $T_{1/2}$ = 2.5(5) ps was determined. This measurement was possible thanks to an innovative method involving the use of three types of targets with different substrates (Si, Ti, Ta), allowing the control of the stopping times of recoils. The result confirms the intruder nature of the state, evidenced by a reduced B(E2) transition probability of ~0.045 W.u., in accordance with theoretical modeling and in contrast to the states of normal configurations that deexcite with significantly higher transition probabilities, on the order of 4 W.u.

In addition, the test experiment for the study of the ^{38}S nucleus was performed, performed by a transfer reaction of 2 neutrons in inverse kinematics ^{18}O(^{36}S, ^{38}S)^{16}O by using a ^{36}S beam accelerated to 60-64 MeV and the isotopically enriched $Ta_2{}^{18}O_5$ target. Such targets were produced by anodization for the first time in the Target Laboratory of the Department of Nuclear Physics of IFIN-HH. This test experiment led to the preliminary identification of a new energy level at ~2.4 MeV, a candidate for the intruder state theoretically predicted in ^{38}S. In the next stage of the project, the complete experimental campaign dedicated to the ^{38}S nucleus will be carried out, through which we will determine the spin of this newly discovered state.