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Study of multiple shape coexistence in 80Zr and isospin symmetry breaking of its vicinity

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Nuclear physicists have kept their attention to the nuclei that the proton number (Z) and the neutron number (N) are same, i.e. N=Z, because they are interesting for several reasons. First, they provide a test ground of exchange symmetry between protons and neutrons. Approximately, the nuclear force acting between nucleons does not distinguish the kind of nucleons. However, each proton has a charge, thus Coulomb force affects the configuration of nuclei. It implies that the nuclei that consist of (Z, N+1) and (Z+1, N) show a different behavior due to the charge difference even if their number of nucleons are same.

Second, some theoretical predictions suggest the emergence of multiple shape coexistence in N=Z nuclei [1]. The phenomenon has been observed for 16O and 40Ca. 80Zr can pose five different shapes, spherical, prolate, and three different triaxial according to Ref. [2]. Moreover, 80Zr has a potential of being a dodecahedron shape, one of the platonic solids. A recent research found that the alpha clustering nuclei form a balloon-shaped configuration like a fullerene [3].

In this study, the goal of research will focus on revealing the properties of 80Zr and its vicinity in the nuclear chart. The two main objectives of this study are as follows:

(1) A multiple shape coexistence of 80Zr: this study is aimed at scrutinizing the properties of the low-lying states of 80Zr. A theoretical prediction using beyond mean field approach indicates that the multiple shape coexistence can exist in 80Zr. The experiment will concentrate on the discovery of the hypothetical low-lying 0+ states.

(2) Isospin symmetry breaking around N=40, Z=40: as described above, the isospin symmetry breaking takes place due to Coulomb force. The extent of deviation from the charge-symmetry and charge-independence are presented with the term Mirror Energy Difference (MED) and Triplet Energy Difference (TED), respectively. Mass region A=80-100 are little known due to the difficulty of ion production. However, the development of measurement techniques and ion production mechanism realize the exploration of the proton-rich nuclei. We expect that the nearly symmetric low-lying states can be observed in pairs of 79Zr −79Y, 85Mo −85Tc, and so on. The study of charge-independence and charge-symmetry breaking towards more heavier nuclei will reveal the role of protons in fp shell and its neighboring orbitals in the symmetry breaking.

References

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