Contribution ID: **21** Type: **Talk**

Shape-isomer-like excitations in 64,66Ni isotopes

Tuesday, 3 May 2022 10:00 (15 minutes)

The phenomenon of nuclear shape isomerism, which is an example of extreme shape coexistence in nuclei, arises from the existence of a secondary minimum in the nuclear potential energy surface (PES), at substantial deformation, separated from the primary energy minimum (the ground state) by a high potential energy barrier that hinders the transition between the minima. Shape isomers at spin zero have clearly been observed, so far, exclusively in actinide nuclei [1,2].
In recent years, our collaboration has identified coexistence of spherical, oblate and prolate 0+ excitations in the 64Ni and 66Ni isotopes, in a series of experiments with different reaction mechanisms (i.e., transfer reactions, neutron capture, Coulomb excitation, and nuclear resonance fluorescence (NRF)). In both systems, ⊠ decay from the prolate 0+ state showed significant hindrance (B(E2) < 0.08 W.u. and B(E2) = 0.2 W.u. in 64Ni and 66Ni, respectively) which, according to Monte Carlo Shell-Model calculations, arises from a prolate-to-spherical shape-changing transition through a high barrier [3,4]. These prolate 0+ states were named "shape-isomer-like" excitations. Their appearance at low excitation (below 3.5 MeV) reflects the action of the monopole tensor force, and it is often referred to as Type II shell evolution [5]. It involves particle-hole excitations of neutrons to the g9/2 unique-parity orbital from the fp shell. Extra binding for such intruder states is provided largely by the monopole tensor part of the nucleon-nucleon force (the proton f5/2-f7/2 spin-orbit splitting is reduced, favoring proton excitations across the Z=28 shell gap), and stabilizes isolated, deformed local minima in the PES.
An analogous situation is expected to occur in the 112,114Sn isotopes, but with neutron excitations to the h11/2, unique-parity orbital playing the same role as the g9/2 neutron excitations in the Ni nuclei and inducing the reduction of the proton g7/2-g9/2 spin-orbit splitting (similarly to the proton f5/2-f7/2 one in Ni). New experiments are planned to study the properties of these systems using both two-neutron and two-proton transfer reactions and state-of-the art gamma-spectroscopy techniques.

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Session Classification: Isomers in Nuclear Structure and Astrophysics ONLINE