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Search for shape isomers by using sub-barrier transfer reactions with radioactive beams

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For the collaboration:
S. Leoni et al., *University of Milano and INFN sez.-Milano, Italy*
B. Fornal et al., *Institute of Nuclear Physics PAN, Krakow, Poland*
N. Marginean et al., *IFIN HH, Bucharest, Romania*
M. Sferrazza, *Universitè libre de Bruxelles, Bruxelles, Belgium*
T. Otsuka et al., *University of Tokyo, Tokyo, Japan*

The phenomenon of shape isomerism is related to the existence of a high barrier in the nuclear potential energy surface (PES), separating the primary energy minimum (the ground state) from a secondary energy minimum at large deformation. Shape isomers at spin zero have clearly been observed, so far, only in actinide nuclei - they decay mainly by fission, although in two cases, ^{236}U and ^{238}U, gamma-ray branches with very retarded transitions are known [1,2]. Recently, we have identified a shape-isomer-like structure at spin zero in a very light nucleus ^{66}Ni by using gamma-ray spectroscopy and employing the two-neutron transfer reaction induced by an ^{18}O beam on a ^{64}Ni target, at the sub-Coulomb barrier energy –the experiment was performed at the Tandem Accelerator Laboratory of the IFIN HH in Bucharest [3]. The study was inspired by various mean-field theoretical approaches [4,5,6] as well as by the state-of-the-art Monte Carlo Shell Model Calculations [3]: the ^{66}Ni nucleus turned out to be the lightest nucleus for which all models indicate the existence of a pronounced secondary prolate PES minimum. Our finding, by showing that shape isomerism is characteristic not only for very heavy nuclei, sheds light on the microscopic origin of nuclear deformation.
Shape isomerism at spin zero is expected to be a more common phenomenon. In fact, the mentioned mean-field theoretical models [4-6], as well as the recently published macroscopic-microscopic calculations [7], predict relatively deep secondary PES minima in nuclei in few other regions of the nuclear chart. For example, such minima associated with a sizable deformation should exist in nuclei Pt, Hg and Pb with neutron number around N=110, and in Pd, Cd and Sn with N$\sim$66. A possibility will be discussed for identifying gamma decay out of these minima, by employing two- and one-neutron or two- and one-proton sub-barrier transfer reactions induced by radioactive beams of Tl from HIE-ISOLDE and Ag from SPES, on stable targets.

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Author: FORNAL, Bogdan (IFJ PAN, Krakow)

Presenter: FORNAL, Bogdan (IFJ PAN, Krakow)