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Shape Isomerism in 66Ni

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The phenomenon of shape isomerism is related to the existence, in the nuclear potential energy surface (PES), of a secondary minimum associated with large deformation and separated from the primary minimum (ground state) by a high barrier. Shape isomers at spin zero have clearly been observed, so far, only in actinide nuclei. The existence of shape isomers in lighter systems has been a matter of debate for a long time: a rather restricted number of candidates was suggested by various mean-field theoretical approaches [1,2,3] and 66Ni turned out to be the lightest nucleus for which all models indicate the existence of a pronounced secondary PES minimum.
In 66Ni, among the six lowest excitated states three have spin-parity assignment 0+. Monte Carlo Shell Model Calculations [4] which correctly predict the existence of all these three excited 0+ states, show that the 0+_4 excitation should exhibit well-deformed prolate shape and be separated by a substantial barrier from the spherical main minimum. Indeed, the calculated B(E2) probabilty from 0+_4 into the spherical 2+ is found to be significantly hindered pointing to the 0+_4 state as a candidate for shape isomer.
To check this prediction, we performed a measurement of the lifetimes of 0+ excitations in 66Ni at the Bucharest Tandem Laboratory. By employing the two-neutron transfer reaction 64Ni(18O,16O)66Ni, at sub-barrier energy of 39 MeV, all three lowest-excited 0+ states in 66Ni were populated and their gamma-decay was observed by employing gamma-coincidence technique with the ROSPHERE HPGe array. The population pattern of the 0+ states clearly indicated that 0+_4 corresponds to the prolate deformed 0+ excitation predicted by theory. The 0+ states lifetimes were measured with a plunger device and, in particular, for the 0+_4 to 2+_1 decay the B(E2) values of 0.2 W.u. was found. The measured hindrance of E2 decay from the prolate 0+_4 to the spherical 2+_1 state is in line with the results of MCSM calculations, although the experimental magnitude is smaller. This result makes 66Ni a unique nuclear system, apart from 236U and 238U, in which a retarded gamma-transition from a 0+ deformed state to a spherical configuration is observed, pointing to a shape isomer-like behaviour.
References:
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