Fine structure in proton emission from $^{141g.s.}$Ho and ^{141m}Ho discovered by means of digital signal processing

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Fine structures in the proton emission from the 7/2$^-$[523] ground state and the 1/2$^+$[411] isomeric state in the deformed nucleus ^{141}Ho were discovered at the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory. Proton transitions to the 0$^+$ ground state and to the first excited 2$^+$ state at 202 keV in ^{140}Dy [1] with branching ratios of $I_p^{gs}(2^+)$=0.9±0.1% and $I_p^m(2^+)$=1.7±0.4% were identified.

Two independent experiments were performed. The $^{141g.s.}$Ho and ^{141m}Ho ions were produced in the fusion-evaporation reaction of a 20 to 35 particle nA ^{54}Fe beam impinging on a ^{92}Mo target. Beam energies of 300 MeV and 290 MeV were used for target thicknesses of 1 mg/cm^2 and 0.6 mg/cm^2, respectively. Reaction products were separated according to their mass over charge ratio by the HRIBF Recoil Mass Spectrometer [2]. Selected recoils were implanted into a Double-sided-Silicon-Strip-Detector (DSSD) after passing through a thin-foil position sensitive Micro Channel Plate (MCP) detector and being slowed down by a degrader foil. During the experiment on the 4.1ms $^{141g.s}$Ho activity, signals from all detectors were read by Digital Gamma Finder (DGF) modules [3] set up for standard data acquisition mode (i.e. time and energy analyzed on board). For the measurement of the 7.4μs isomeric decay, the detection system was improved by adding four 0.7 mm thick Si detectors forming the sides of a box upstream of the DSSD to veto events related to escaping protons or β particles. Due to the short half-life of ^{141m}Ho, the DGF modules serving the DSSD detector worked in a so-called 'proton-catcher' mode [4]. In this mode the digital electronics is programmed to record only those events where the signal of the implanted recoil is followed by the decay signal within the 40μs time range [5]. Subsequently only the 'oscilloscope-like snapshots' (traces) containing both recoil and decay signals were stored for further offline analysis.

The structure of the $^{141g.s}$Ho and ^{141m}Ho wave functions, in particular the components responsible for the proton emission process, will be discussed. The decay properties of ^{141gs}Ho can be explained by assuming a small triaxial deformation ($\gamma \approx 5^\circ$ - 10°). However, the observed $I_p^m(2^+)$ value is much higher than current theoretical expectations. The experimental observations suggest only a small (3%) contribution of the $\pi s_{1/2} \otimes 0^+$ component to the 1/2$^+$[411] isomeric state wave function.

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