New Level Scheme of ^{212}Rn

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INTRODUCTION

For many years, the spherical nuclei near the doubly closed shell nucleus $^{208}_{82}Pb_{126}$ have provided a laboratory in the heavy-element region in which the large-scale shell model had been compared with experiments [1, 2]. Therefore, it is particularly important to have complete experimental data in this mass region. A large amount of information on nuclei near ^{208}Pb has been obtained through a wide variety of experiments. Nevertheless, there are many gaps in the data.

The nucleus ^{212}Rn, with its relatively simple structure of a closed neutron core and four valence protons outside the doubly closed shell ^{208}Pb core, provides a convenient system of nuclei for testing the study of both low- and high-spin states and has received much attention in the past few decades. The first study [3, 4] of the high-spin level structure of ^{212}Rn used the ^{204}Hg(^{13}C, 5n)^{212}Rn reaction to establish the basic structure of the nucleus to an excitation energy of about 8.5 MeV, some involving double neutron core excitations. Afterwards, a number of isomers and high-lying γ-ray transitions were observed [5–7]. Recently, G. D. Dracoulis *et al.* [8, 9] using the ^{204}Hg(^{13}C, 5n)^{212}Rn and the ^{198}Pt(^{18}O 4n)^{212}Rn reactions extended the level scheme to higher spin ($39\hbar$), with an excitation energy in excess of 13 MeV, covering states formed by aligned valence protons combined with single, double, and triple neutron-core excitations. These were interpreted in terms of both the empirical shell model (ESM) and the deformed independent particle model (DIPM). Lifetimes, g-factors and magnetic moments were also measured by different groups and interpreted them in terms of diverse microcosmic model [4, 10–13, 15]. To sum up, previous studies of the in-beam γ-ray spectroscopy have provided some details on the energies and decay characteristics of intermediate-high spin states in ^{212}Rn. However, these studies have produced no information at all about the levels of $\pi h^2_{9/2} f^2_{7/2}$ configuration, for the $\pi h^3_{9/2} f_{7/2}$ and $\pi h^3_{9/2} i_{13/2}$ configurations with $J \leq 6$, the data are inadequate or nonexistent, and particularly the extremely interesting collective 3^- state is absent. Therefore, much more low-lying information is needed about γ-decay properties, which are a sensitive probe of the wave functions.

The experimental results reported in this paper were obtained in the course of a study of reaction mechanisms induced by the weakly bound ^{6}Li nucleus on a ^{209}Bi target, the details of which will be described in future paper. The level scheme established as a result of the present investigation differs in several important aspects from that of previous work. The reaction ^{209}Bi(^{6}Li, 3n)^{212}Rn with beam energies of 28, 30, and 34 MeV in the present work would result in a favored population of non-yrast states compared to previous heavy-ion experiments, and more side-feeding into the 2^+, 4^+, and 6^+ states.

EXPERIMENT AND RESULT

The experiment was performed at the Tandem-XTU accelerator of Legnaro National Laboratory in Italy. The target consisted of a 500 μg/cm^2 ^{209}Bi backed with a 100 μg/cm^2 C foil. The de-excitation γ rays from the reaction residues were detected with the GALILEO γ-ray array which is made of 25 Compton-Suppressed bismuth germanate high-purity germanium (BGO-HPGe) detectors distributed on four rings: ten detectors at 90°, five detectors at each of the following angles 119°, 129°, and 152°. The relative photo peak efficiencies of detector array and energy calibrations were performed using ^{60}Co, ^{137}Cs, ^{152}Eu and ^{133}Ba standard radioactive sources.

A total of 8.4×10^9 γ - γ two and higher fold coincidence events were recorded. The data were sorted into symmetrized and angular correlation γ-γ matrices for off-line analysis. An asymmetric angular correlation matrix

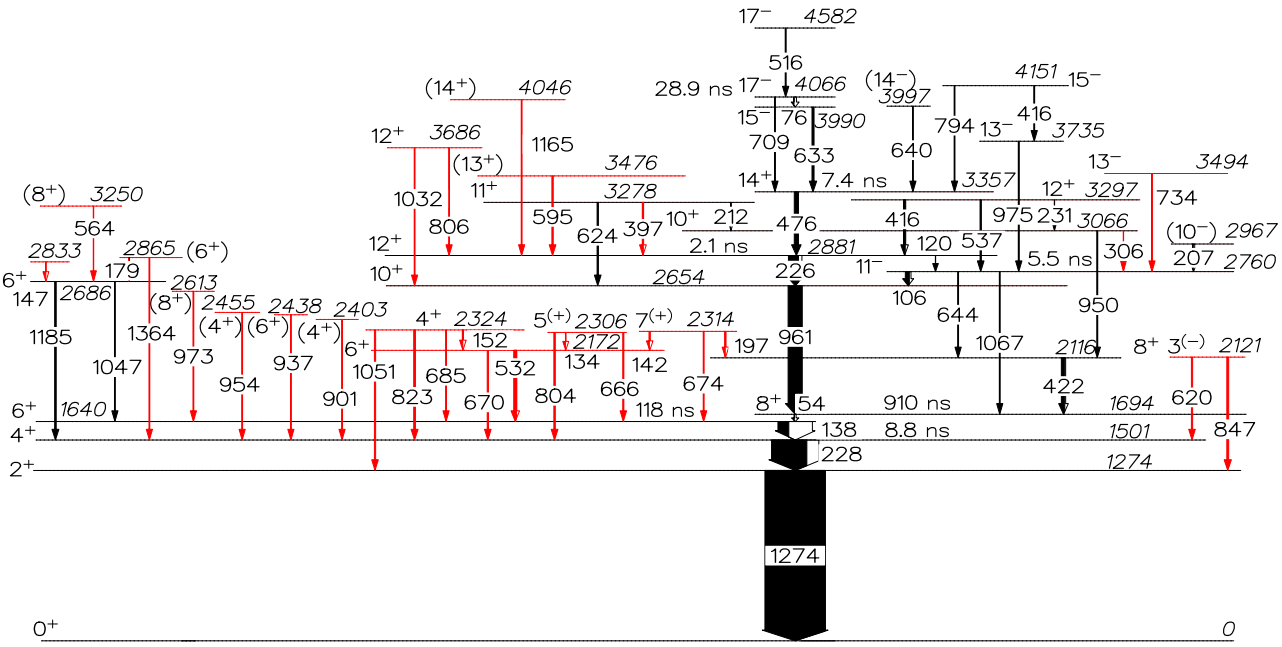


Fig. 1. Partial level scheme of ^{212}Rn in the present work. Newly assigned levels and γ transitions are marked by red colour. The arrow widths are approximately proportional to the relative γ-ray intensities, while the white part of the arrows is the correction due to internal conversion [14]. The evaluated half-lives in Ref. [15] for the isomeric states are also indicated.

between the detectors at 152° and at 90° was constructed and used for the directional correlation of oriented states (DCO) ratio analysis to distinguish between quadrupole and dipole transitions. In our array geometry, a DCO ratio of about 1.0 is expected if the gating and the observed transition are stretched transitions of pure and equal multipole order. $R_{DCO} \approx 0.6$ is expected for a pure dipole transition gated on a stretched quadrupole transition. Spin and parity indicate assignments with high confidence are based upon previously reported data, our DCO measurements, systematic considerations and shell model calculations. Unbracketed assignments in figure 1 indicate the highly probably assignments, while more speculative spin assignments are indicated in parentheses.

In the present experiment, the light-mass beam excited more low-spin non-yrast states, so no higher spin states information is established. The previously reported level schemes below 17ħ are for the most part confirmed, and about 29 new γ transitions and 16 new levels are placed in the intermediate-low spins of the level scheme. In particular, several unplaced γ-rays from very early decay works [15] are assigned.

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