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Nuclear Physics A 756 (2005) 83–117
NUCLEAR PHYSICS A

High spin states in ^{210}Rn approaching the region of 3-particle–hole neutron excitations

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Received 20 January 2005; received in revised form 15 March 2005; accepted 21 March 2005

Available online 9 April 2005

Abstract

The properties of high spin states in ^{210}Rn have been investigated using the ^{198}Pt(^{17}O, 5n) reaction at a bombarding energy of 96 MeV. Decay properties for states up to an excitation energy of $12026 + \Delta$ keV and spin of (37^-) have been deduced. The level scheme is compared with predictions of empirical shell model calculations. High lying states are interpreted in terms of multiparticle configurations which include single and double neutron core excitations. Configurations have been assigned for almost all of the observed levels. Agreement between experimental and calculated level energies is generally within 200 keV.

Keywords: NUCLEAR REACTION ^{198}Pt(^{17}O, 5n), $E = 96$ MeV; measured prompt and delayed E_γ, I_γ, $\gamma\gamma$-coin, $E(ce)$, $I(ce)$. ^{210}Rn deduced high-spin levels, J, π, ICC, configurations. Enriched target, pulsed beam, superconducting electron spectrometer.
NUCLEAR STRUCTURE ^{210}Rn; calculated levels, J, π, configurations. Semi-empirical shell model, neutron core excitation.

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0375-9474/$ – see front matter
doi:10.1016/j.nuclphysa.2005.03.020

1. Introduction

For many years, the spherical nuclei near the doubly closed shell nucleus $^{208}_{82}\mathrm{Pb}_{126}$ have provided a laboratory in which the semi-empirical shell model and the multiparticle octupule coupling model have been confronted by experiment. The radon nuclei have provided a particularly rich testing ground and $^{210}_{86}\mathrm{Rn}_{124}$ has received much attention.

The first investigation [1] of the nuclear structure of ^{210}Rn used the ^{204}Pb $(^{9}\mathrm{Be}, 3n)^{210}$Rn reaction to establish the basic structure of the nucleus to an excitation energy of 3.8 MeV and provided a simple shell model interpretation of the level structure. Shortly after, using the $^{205}\mathrm{Tl}(^{10}\mathrm{B}, 5n)^{210}$Rn reaction, Poletti et al. [2] showed that there were two low lying 4^+ states and interpreted their existence in terms of a competition between neutron–hole and proton excitations. Magnetic moments of four isomers were measured by Maier et al. [3] using the $^{202}\mathrm{Hg}(^{12}\mathrm{C}, 4n)^{210}$Rn reaction and a liquid mercury target. These were interpreted in terms of the shell model structure of the levels and were also used to correct previously suggested [1] spin and parity assignments to the levels at $3248 + \Delta$ and $3812 + \Delta$ keV (where Δ is the unknown energy gap between the yrast 8^+ and 6^+ states).

As well as the $^{205}\mathrm{Tl}(^{10}\mathrm{B}, 5n)^{210}$Rn reaction, Poletti et al. [4] used ^{198}Pt $(^{16}\mathrm{O}, 4n)^{210}$Rn and ^{198}Pt $(^{17}\mathrm{O}, 5n)^{210}$Rn reactions to established the level structure in detail to an energy of $8556 + \Delta$ keV and $J^{\pi} = 28^+$ as well as identifying higher lying transitions up to a level of proposed spin $(31, 32)$ at an excitation energy of $10087 + \Delta$ keV. The strong E3 transitions discovered in ^{210}Rn were discussed and shell model calculations were carried out for the valence particle states. A feature of the nuclear structure of ^{210}Rn is the 1.50 μs isomer at $6469 + \Delta$ keV which decays mainly via an extremely inhibited E2 transition. An explanation of this was provided in terms of a neutron core excitation model and higher lying states were also interpreted as being (singly) core excited.

Information on short lived isomers was reported by Poletti et al. [5], including a mean life for the $8556 + \Delta$ keV level of 2.6(3) ns which gave a strength of 53(6) Weisskopf units for the 1245 keV E3 transition de-exciting the isomer.

The $^{202}\mathrm{Hg}(^{12}\mathrm{C}, 4n)^{210}$Rn reaction, was used by Poletti et al. [6] to determine magnetic moments for six isomers. Good agreement for the three lower lying isomers was found with the earlier work of Maier et al. [3]. In addition, magnetic moments were determined for the isomeric states at $7311 + \Delta$, $6469 + \Delta$ and $4993 + \Delta$ keV, respectively. A feature of this work was the interpretation of the structure of the levels in terms of the multi particle octuple coupling (MPOC) model, which successfully, and simultaneously, explained the level energies, magnetic moments and large E3 enhancements in terms of the coupling between the E3 vibrational and shell model degrees of freedom.

Berger et al. [7] used the $^{209}\mathrm{Bi}(^{6}\mathrm{Li}, 5n)^{210}$Rn reaction on a bismuth single crystal to measure the quadrupole moments of the yrast 17^- and 8^+ states and inferred rather small deformation parameters, β, of 1.3(4)% and 1.2(2)% respectively, giving confidence that a shell model approach should continue to be applicable.

The present study is part of a broader programme of measurements focussed on the highest spin states attainable in the ^{210}Rn, ^{211}Rn and ^{212}Rn isotopes. In the latter two cases, high lying isomers have been found [8]. In addition, the understanding of the decay properties of the yrast levels was improved and many new near yrast levels and decay paths were found. Results for ^{211}Rn have been reported and interpreted in Ref. [9], where states