Spectroscopy of heavy isotopes of Hg and Au from incomplete fusion reaction

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Introduction

The heavy isotopes in Pt-Au-Hg region have been known to be transitional in character with structure intermediate between well-deformed prolate shape - a characteristic of rare-earth nuclei, and spherical shell model structure - a characteristic of the nuclei near the doubly magic ^{208}Pb. In the even isotopes of Hg, an intersection of rotation aligned bands based on $\nu i_{13/2}^{-2}$ and $\pi h_{11/2}^{-2}$ configurations with the ground state band have been observed systematically [1]. For the corresponding odd-A Hg isotopes, decoupled bands built on the $i_{13/2}$ orbital have been identified [2]. On the other hand, for the neighbouring odd-odd and odd-even isotopes of Au, the spectroscopic information on the excited states are rather very limited. In most of the cases, data were obtained either from light ion transfer reaction or from the neutron induced reaction. Recently, there have been renewed interests for heavy odd-odd Au isotopes to test the extended super-symmetric model predicted long ago [3]. Population of excited high spin states of heavy isotopes of these nuclei is difficult via conventional heavy ion fusion evaporation reaction. It has been shown that in case of weakly bound nuclei, such as, ^{6,7}Li, ^{9}Be, incomplete fusion processes, generally known as breakup-fusion, can have significant contribution to reaction cross section [4,5] to access some of the heavier isotopes with Z=78-80.

Experiment and Data Analysis

The excited states in ^{199,200}Hg and ^{198,199}Au were populated via the alpha and triton breakup channels, respectively, of incomplete fusion reactions from ^{198}Pt(^{7}Li,xn) at beam energy of 45 MeV obtained from Pelletron LINAC Facility, Mumbai, India. These reactions corresponds to about 26 MeV and 19 MeV of alpha and triton energies for the respective breakup channels. The gamma transitions from the excited states of the above nuclei have been detected using 15 Clover detectors of Indian National Gamma Array, presently setup at TIFR, Mumbai. The target was a 1.3 mg/cm^2 enriched ^{198}Pt self supporting foil. The detectors were arranged in six angles with two clovers each at ±40° and ±65° while four clovers were at 90° and three were at -23°. A digital data acquisition system having digitization rate of 100 MHz, implemented for the first time with INGA, was used. The time-stamped, trigger-less data was obtained with the condition of γ-γ coincidence, ensured at the clover level. From the raw data, γ-γ matrices and γ-γ-γ cubes, with various conditions of time window have been made. For the DCO analysis, a γ-γ matrix with -23^o detectors and 90^o detectors has been generated.

Results and Discussion

Because of the presence of many nearby gamma ray energies at different nuclei in this mass region, the coincidence relations between various transitions have been obtained mainly from the analysis of γ-γ-γ cube data for identification of the transitions of a particular nucleus. Fig.1 shows the coincidence spectra of double gates corresponding to the transitions in ^{199}Hg and ^{200}Hg. In ^{199}Hg, excited states were

studied earlier by alpha induced fusion evaporation reaction and using one Ge(Li) and a planner Ge detector for coincidence measurement [6]. A positive parity band built on the $13/2^+$ isomeric state was observed with tentative spin-parity assignments. It is not possible to populate very high spin states with alpha induced reaction. However, because of the higher efficiency INGA array, used in the present work, the data could be obtained with high statistics for ^{199}Hg nuclei. Therefore, more complete information with definite spin parity assignments are expected to be possible.

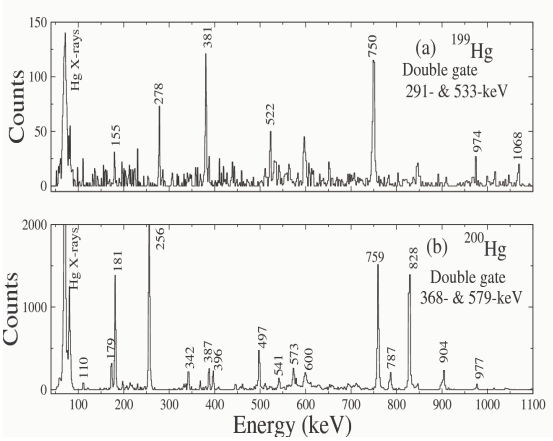

Fig. 1 Coincidence spectra corresponding to a double gate of transitions (a) 291&533 keVof ^{199}Hg, (b) 368&579 keV of ^{200}Hg.

For even-A Au nuclei, a long lived 12^- (11^-) isomer is known to exist for $^{194\text{-}200}$Au isotopes. The configuration of this isomer has been assigned as ($\pi h_{11/2} \otimes \nu i_{13/2}$). Decay from this isomer to the low-lying 8^+ state through a M4 (E3) transition has been observed for $^{194\text{-}198}$Au [7,8,9]. The low-lying 5^+ to 8^+ states in ^{192,198}Au are considered to form a multiplet of ($\nu i_{13/2}^{-1} \otimes \pi d_{3/2}^{-1}$) configuration. A band with a rotation-aligned structure, based on the 7^+ state and extended upto 13^+ level, was observed in ^{194}Au bypassing the long lived 12^- isomeric level. Only a few lower members of this band are known in ^{196,198}Au. A preliminary analysis of the present data shows an indication of possible extension of the above band structure in ^{198}Au across the 12^- isomeric level. A double gated spectrum of 204-keV ($6^+ \rightarrow 5^+$) and 180-keV ($8^+ \rightarrow 6^+$) transitions in ^{198}Au, shown in Fig. 2(a), indicates some new transitions. Fig.2(b) shows a double gated spectrum of one of the new transition, viz., 416-keV and 204-keV. This spectrum shows that all other known transitions, in the same cascade, are present. This gives the evidence that 416- and 605-keV transitions are, possibly, the two new candidates of the same band structure. Further detailed analysis of various gating conditions and the analysis of the DCO and IPDCO matrices are in progress.

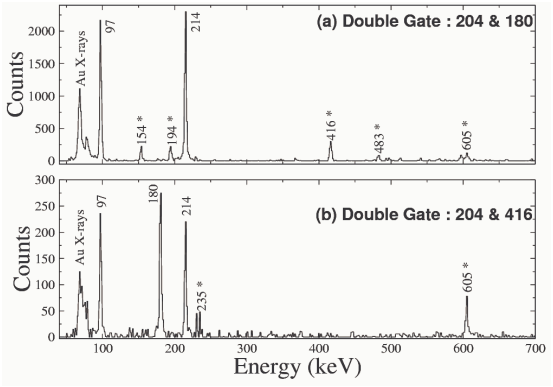

Fig. 2 Coincidence spectra corresponding to a double gate of (a) 204&180 keV, (b) 204&416 keV corresponding to the transitions of ^{198}Au.

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