Shape Coexistence at High Spin in $^{187}$Au

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High-spin states in $^{187}$Au have been populated in the $^{172}$Yb($^{19}$F, 4$n$) reaction and studied with in-beam spectroscopic techniques using the “Château de Cristal” 4$\pi$-multidetector array. A comprehensive level scheme of $^{187}$Au has been established. Experimental band crossing frequencies and gains in alignment were deduced. Shape coexistence in $^{187}$Au, well established at low spin, is found to survive up to spin $57/2$, and manifests itself through well separated oblate and prolate structures.

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1. Introduction

Odd-$A$ gold nuclei with $A \leq 189$ were among the first examples of shape coexistence revealed by means of nuclear spectroscopic studies from radioactive decay of mass-separated sources and heavy-ion induced reactions [1–5]. The proton Fermi level for gold nuclei lies between the $\pi h_{11/2}$ and $\pi h_{9/2}$ subshells, and, for $A \leq 189$, shape coexistence manifests itself, already at low spin, through two $\Delta I = 2$ decoupled bands involving the odd proton in the $h_{11/2}$ orbital and in the $h_{9/2}$ orbital which are characteristic of oblate shape and prolate shape respectively. The $\pi h_{11/2}$ band-head energy remains quite constant throughout the odd-$A$ gold isotopes while the $\pi h_{9/2}$ one (together with the $\pi i_{13/2}$ band head situated a few hundred keV above) decreases steeply with $A$. In $^{187}$Au, the $\pi h_{9/2}$ band head becomes lower than the $\pi h_{11/2}$ one though the $1/2^+$ ground state still corresponds to an oblate shape [6]. In $^{185}$Au, the $5/2^-$ member of the $\pi h_{9/2}$ prolate band becomes the ground state [7]. The strong and constant hindrance factor of the $11/2^-$ to $9/2^-$ interband transition throughout the odd-mass Au nuclei [8] is noteworthy.

Measurements of the $\gamma$-multiplicity following the $^{173}$Lu($^{16}$O, 4$n$) reaction [9] seem to indicate that shape coexistence survives in $^{187}$Au to quite high-spin values. Calculations within the cranked Nilsson-Strutinsky framework [10] show that the collective prolate minimum in the deformation-energy surface of $^{183}$Au survives to spins up to $50$–$55\hbar$ while the minimum in the $\gamma = -60^\circ$ to $-120^\circ$ sector ends for spins $40$–$45\hbar$.

The use of large efficiency multidetector 4$\pi$-arrays for $\gamma$ spectroscopy offers nowadays the possibility to detect discrete transitions deexciting weakly populated high-spin states. We have used the “Château de Cristal” multidetector array [11] to study the states of $^{187}$Au in order to follow the shape coexistence at high spin, and to try to identify the orbitals which are involved in the different structures observed in $^{187}$Au, especially to check the role of the intruder low-$\Omega$ high-$j$ orbitals.

Results on $^{187}$Au high-spin states have already been presented by Johansson et al. [12]. Data on conversion electrons have been obtained by Vieu et al. [13]. The present work gives an enlarged version of the level scheme of $^{187}$Au.

2. Experimental Methods

Levels of $^{187}$Au were populated in the $^{172}$Yb($^{19}$F, 4$n$) reaction at the MP Tandem accelerator at Strasbourg. Targets, 1 mg/cm$^2$, enriched to 92.5%, were deposited on 0.1 mm lead backing. Gamma-rays were detected by the “Château de Cristal” set-up consisting of 12 Compton-suppressed high-purity germanium detec-
Fig. 1. Level scheme of $^{187}_{79}$Au. Energies are labeled in keV. The width of the arrows stands for the total intensity of the transitions. The spin values are multiplied by 2. Part 1: Bands exhibiting collective behavior. The inset represents the deexcitation pattern of the low-energy states as observed in the decay of $^{187}_{79}$Hg [5, 8, 16]. Part 2: Systems of levels with non-collective behavior.