First Observation of Multiple Transverse Wobbling Bands of Different Kinds in ^{183}Au

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We report the first observation of two wobbling bands in ^{183}Au, both of which were interpreted as the transverse wobbling (TW) band but with different behavior of their wobbling energies as a function of spin. It increases (decreases) with spin for the positive (negative) parity configuration. The crucial evidence for the wobbling nature of the bands, dominance of the $E2$ component in the $\Delta I = 1$ transitions between the partner bands, is provided by the simultaneous measurements of directional correlation from the oriented states ratio and the linear polarization of the γ rays. Particle rotor model calculations with triaxial deformation reproduce the experimental data well. A value of spin, I_m, has been determined for the observed TW bands below which the wobbling energy increases and above which it decreases with spin. The nucleus ^{183}Au is, so far, the only nucleus in which both the increasing and the decreasing parts are observed and thus gives the experimental evidence of the complete transverse wobbling phenomenon.

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Nuclear wobbling excitation is a manifestation of nonaxial nuclear shape, which was first discussed by Bohr and Mottelson [1]. The nonaxial (triaxial) nuclear shape appears due to the unequal nuclear mass distribution along the three principal axes and implies three unequal moments of inertia about the three principal axes. A triaxially deformed nucleus always tries to rotate around the medium (m) axis having the largest moment of inertia but the presence of the rotations around the other two axes, i.e., short (s) and long (l), generates a precession of the medium axis rotation about the space-fixed angular momentum axis, similar to the classical wobbling motion of an asymmetric top [2]. The energy spectrum of this excitation is given by [1]:

$$E = E_{\rm rot} + (n_w + 1/2)\hbar\omega_{\rm wob}$$

where, the term $E_{\rm rot}$, corresponds to the rotation about the medium axis while n_w is the wobbling quanta and $\omega_{\rm wob}$ is the wobbling frequency with wobbling energy $E_{\rm wob} = \hbar\omega_{\rm wob}$. This generates a series of rotational bands with different n_w.

This exotic excitation has been observed only in a few odd-A nuclei [3–13]. In case of the odd-A nuclei, the odd particle in high-j orbital couples with a triaxial core and modifies the wobbling motion. Depending on the coupling of the odd particle, two types of wobbling bands can be observed: longitudinal wobbling (LW) and transverse wobbling (TW) [14]. In LW, the angular momentum of the odd particle aligns along the medium axis while in TW, it aligns along one of the perpendicular axes (short or long).

An extensive theoretical description of the wobbling motion has been given by Frauendorf and Dönau [14] in terms of a quasiparticle triaxial rotor model. Analytical expression for $\hbar\omega_{\rm wob}$ has been derived with the assumption of "frozen alignment" and harmonic oscillation (HFA). It was shown that $E_{\rm wob}$ increases as a function of angular momentum (I) in case of LW which has been recently observed experimentally in ^{133}La [10] and ^{187}Au [12]. However, in case of TW, the variation of $E_{\rm wob}$ is highly dependent on the values of the moments of inertia, $\mathcal{J}_m$, $\mathcal{J}_s$, and $\mathcal{J}_l$ along the medium, short, and long axes, respectively, of the triaxial core. In general, $E_{\rm wob}$ decreases with I. But in a situation where $\mathcal{J}_m$ is slightly larger than $\mathcal{J}_s$ and

