Shapes of stable Ir and Pt transition nuclei

A. M. Goryachev and G. N. Zalesnyĭ

Mechanics and Physics Research Institute

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We measured the photoabsorption cross sections in the region of the giant dipole resonance for the nuclei ^{191,193}Ir and ^{194,195,196,198}Pt. The assumed presence of oblate deformation of these nuclei is not confirmed within the framework of the performed analysis.

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The study of the collective properties of the transition nuclei W, Os, and Pt has recently attracted persistent attention of both theoreticians and experimenters. K. Kumar[1] has proposed earlier[1] that a transition from a prolate to an oblate shape takes place in the region between the stable isotopes of Os and Pt. The predicted reversal of the sign of the quadrupole moment of the first 2^+ state was observed experimentally[2]; the Os isotopes have $Q_{2^+} < 0$ (prolate nuclei), while the stable isotopes of Os have $Q_{2^+} > 0$ (oblate nuclei). Recent experimental evidence,[3] however, based on an analysis of the spectra of nuclei with odd A, points to a possible asymmetric shape of the nuclei Os and Pt. Calculations do not call for asymmetry in nuclei of this region, with the exception of the heavy Os isotopes and the lightest Pt isotopes.

One can attempt to obtain information on the shape of heavy transition nuclei by investigating the behavior of the cross section of the giant dipole resonance (GDR).

It is known[4] that for deformed nuclei the GDR splits into two maxima corresponding to oscillations in the perpendicular plane. Depending on whether the nuclei is prolate or oblate, the ratio of the probabilities of the excitation of the low- and high-energy maxima will be 1:2 or 2:1. The presence of static nonaxiality lifts the degeneracy of the transverse oscillation mode.[5] The coupling of the dipole and quadrupole oscillations produces an additional splitting of the transverse and longitudinal modes,[6] with a value determined by the rms amplitude of the zero-point oscillations of the nuclear surface.

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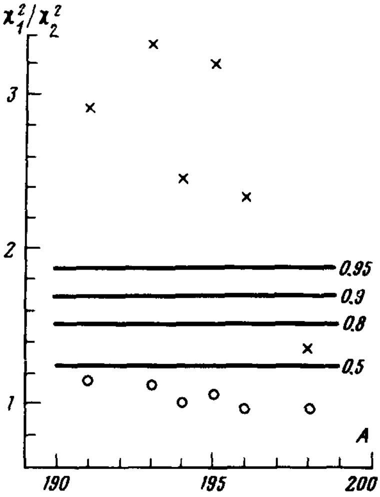

FIG. 1. Ratios of χ^2 of the tested hypotheses. Crosses—χ_1^2/χ_2^2. Circles—χ_3^2/χ_2^2. The horizontal lines are the boundaries of the confidence interval of the *F* criterion for several significance levels $\alpha = 0.5$, 0.8, 0.9, and 0.95.

Since the GDR for heavy nuclei is confined in the main to the reactions (γ,*n*) and (γ,2*n*), it suffices to investigate the behavior of the photoneutron cross section.

The cross sections of the photoabsorption by the isotopes ^{191,193}Ir and ^{194,195,196,198}Pt were measured using a bremsstrahlung beam from a betatron with photons in the range from 7 to 20 MeV in steps of 0.2 MeV. The measurement apparatus operated on line with a computer.[7] Simultaneously with the yield curves, we measured by a statistical method[8] the photoneutron-multiplicity curves, making it possible to determine correctly the photoabsorption cross section from the experimental data. The cross sections were calculated from the yield curve by the Pnefold-Leiss method in steps of 1 MeV.

To ascertain the shapes of the investigated nuclei, the experimental data on the photoabsorption cross section were used to varify the following hypotheses:

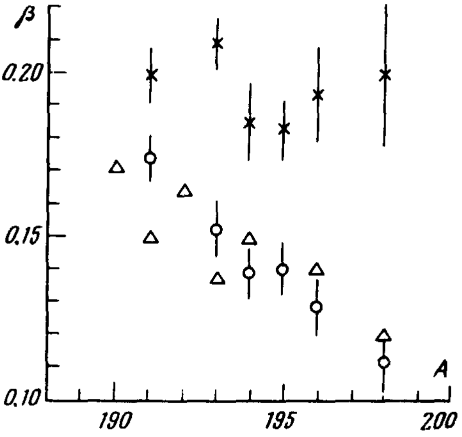

FIG. 2. Absolute values of the quadrupole deformation parameter calculated under the assumption that hypothesis (2) is valid (circles). The same for hypothesis (3) (crosses). The values known from *B* (E2, $0^+ \rightarrow 2^+$) (triangles) are also shown.

(1) the cross section is described by a single Lorentz curve (spherical nucleus); (2) the cross section is described by a sum of two Lorentz curves with area ratio 1:2 (prolate nucleus); (3) the same with area ratio 2:1 (oblate nucleus). Figure 1 shows the obtained ratios of χ^2 of these hypotheses. Figure 1 indicates also the boundaries of the confidence interval of the F criterion[9] for several significance levels. It is seen that hypotheses (1) is rejected with probability >95% for all the nuclei with the exception of ^{198}Pt. Hypotheses (2) and (3) yield an equally good description of the experimental data. An attempt can be made to distinguish between them by considering the consequences that follow from them. It is known that for a deformed nucleus the energies of the transverse and longitudinal modes are connected with the nuclear quadrupole-deformation parameter β in the following manner:

$$E_{\perp} / E_{\parallel} = (1 + 0.6055\,\beta) / (1 - 0.2649\,\beta).$$

Figure 2 shows the values of $|\beta|$ calculated in the case when hypotheses (2) (circles) and (3) (crosses) are valid. The errors indicated correspond to the uncertainty in the estimates of $E_{\perp}$ and $E_{\parallel}$ from the experimental cross sections. It is seen that the assumption that Ir and Pt are oblate nuclei leads to an excessive over-estimate of the values of $|\beta|$. The hypothesis that the nucleus is prolate yields values of β that agree well with the values obtained from $B(\mathrm{E2},\, 0^+ \to 2^+)$[10] (shown by triangles in Fig. 2). In addition, the widths of the transverse maximum for the Ir and Pt isotopes exceed by 15—20% the known values for the isotopes of Hf and W,[11] thus indicating either the presence of static non-axiality or a large contribution of the interaction with the γ vibrations of the surface.

Thus, the presented analysis of the experimental data does not confirm that the isotopes of Ir and Pt are subject to oblate deformation.

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