GIANT DIPOLE RESONANCE FOR THE NUCLEUS ^{181}Ta

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Submitted 13 June 1969
ZhETF Pis. Red. 10, No. 2, 80 - 84 (20 July 1969)

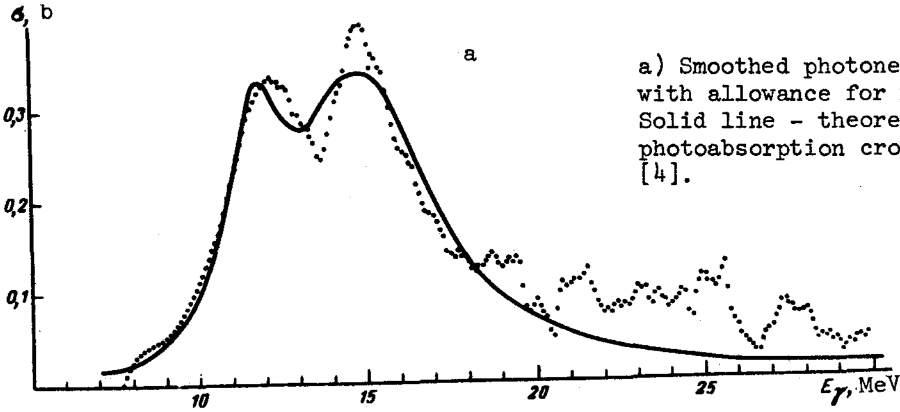
In a number of experimental papers (cf., e.g., [1, 2]), it was observed that the giant resonance of heavy deformed nuclei consists of two broad maxima shifted in energy relative to each other by several MeV. According to the hydrodynamic model, these maxima correspond to different frequencies of the relative dipole oscillations of the proton and neutron liquids, excited along the major and minor axes of the nuclear ellipsoid. The approximation of the partial resonances by Lorentz lines 2 - 4 MeV wide gives a satisfactory description of the available experimental data. New detailed information on the shape of the giant resonance of heavy nonspherical nuclei would make it possible to establish the limits of applicability of the simplest hydrodynamics photoeffect models to such nuclei, and is essential for the construction of a more exact theory of photodisintegration.

We present here the results of an investigation of the neutron photoproduction cross section for the nucleus ^{181}Ta, performed with the betatron of our institute. The measurements were made from the threshold of the (γ, n) reaction to 30 MeV, in steps of 0.1 MeV. The photoneutrons were registered with a detector of 0.45 efficiency. The yield curve was obtained with the aid of a system for automatic switching of the accelerator and 256-channel registration of the reaction products. The data reduction was by means of the programs of the Computing Center of the Moscow State University [3].

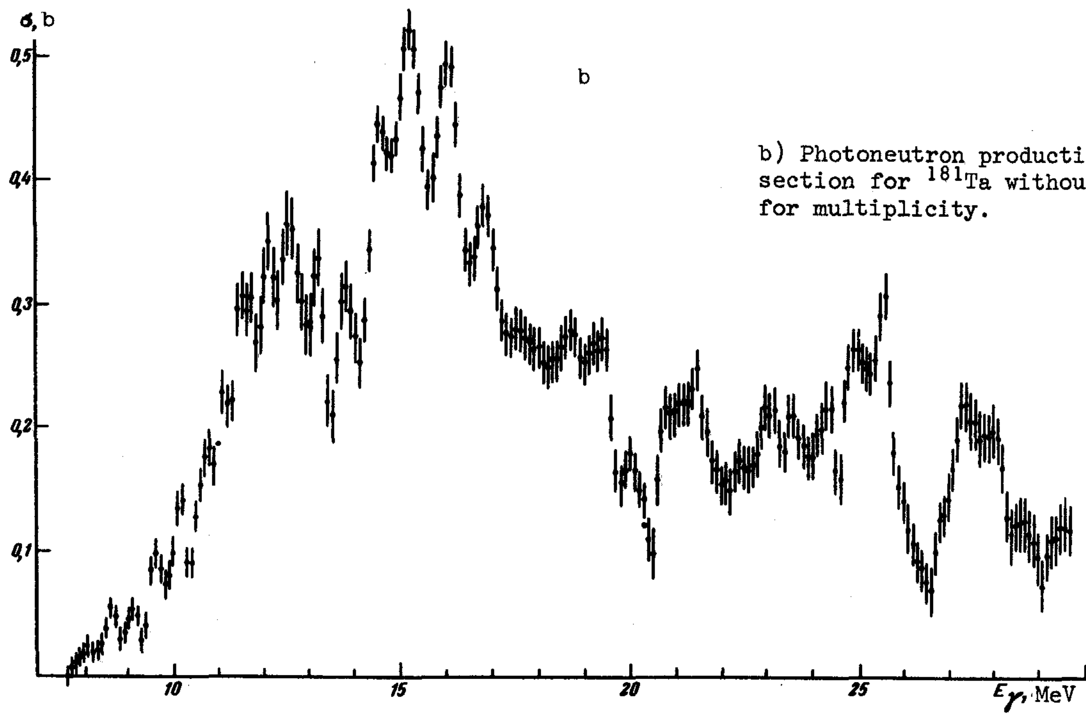
The obtained effective cross section $\sigma(\gamma, n) + \sigma(\gamma, np) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n)$ for ^{181}Ta is shown in Fig. b. The multiplicity of photoneutron production was taken into account using the formulas of the statistical theory with parameters satisfying in the best manner the experimental data of Fultz and co-workers on the cross sections $\sigma(\gamma, n) + \sigma(\gamma, np)$, $\sigma(\gamma, 2n)$, and $\sigma(\gamma, 3n)$ for ^{181}Ta [2]. The total photoneutron cross section corrected for the multiplicity $\sigma(\gamma, n) + \sigma(\gamma, np) + \sigma(\gamma, 3n)$, which is strongly smoothed out in the region to 18 MeV, is represented by the points of Fig. a for convenience in comparison with the earlier measurement data and with the theoretical data. The integral cross sections up to 30 MeV, with and without allowance for multiplicity, turned out to be 3210 ± 300 and 4950 ± 400 MeV-mb.

The general form of the cross section curve obtained by us (Fig. a, points) agrees well with the earlier measurement results [1, 2]. However, the higher energy resolution of this experiment has made it possible to observe, against the background of two broad maxima, narrower resonances which wer not observed previously.

Danos and Okamoto, starting from the simplest hydrodynamic model, have shown that the giant resonance of a strongly deformed axially symmetrical nucleus should split into two maxima. Allowance for the quadrupole surface oscillations (type β and γ) within the framework of the dynamic collective model leads to a certain enrichment of the spectrum of the dipole excitations [4]. Thus, owing to the γ oscillations, the nucleus ceases to be axially symmetrical and the upper maximum corresponding to the dipole oscillations along



a) Smoothed photoneutron cross section w with allowance for multiplicity (points). Solid line - theoretically calculated photoabsorption cross section for ^{181}Ta [4].



b) Photoneutron production cross section for ^{181}Ta without allowance for multiplicity.

the minor axis splits into several additional resonances. However, the number of intense resonances in the cross section remains small as before - not more than 4 - 5. Setting in correspondence with each resonance a smooth curve with half-width 2 - 3 MeV, the authors of [4] obtained the photoabsorption cross section for ^{181}Ta; this is represented by the solid line of Fig. a, but shifted 0.6 MeV to the left. It is obvious that the experimental photodisintegration cross section is much more complicated than the theoretical one and the dynamic collective model can be regarded only as a rough approximation of the experimental data. The discrepancy is particularly large in the 10 - 14 MeV region, where a whole number of maxima with half-width 0.3 - 0.5 MeV is observed, whereas theory yields in this region only one intense resonance with half-width 2 - 3 MeV, corresponding to dipole oscillations along the major axis of the nuclear ellipsoid. The experimentally observed structure may be connected with the existence of levels of particle-hole nature, and therefore microscopic calculations of the dipole resonance of heavy deformed nuclei are necessary. It is also necessary to investigate the influence exerted on the giant resonance by surface oscillations of multiplicity higher than quadrupole.

The fact that the experimental curve lies systematically above the theoretical one in the 20 - 30 MeV region is apparently connected with the presence of giant quadrupole resonance. Calculations performed for ^{159}Tb and ^{165}Ho [5] show that the cross section for the absorption of quadrupole photons, concentrated in the 20 - 27 MeV region, contains five resonances and amounts to 7 - 8% of the total integral photodisintegration cross section.

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VIBRATIONAL RELAXATION OF CO_2 AND N_2 MOLECULES IN AN EXPANDING SUPERSONIC GAS JET

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Submitted 16 June 1969
ZhETF Pis. Red. 10, No. 2, 84 - 88 (20 July 1969)

The study of the vibrational relaxation of CO_2 molecules in a rapidly expanding supersonic gas jet was undertaken in order to develop a gasdynamic laser (GDL) based on a mixture of carbon dioxide and nitrogen [1, 2]. The general idea of devices of this kind was advanced by Hurle and Hertzberg [3, 4], and model calculations of the flow of a carbon dioxide and nitrogen mixture are reported in [2, 3 - 7]. The main idea of the GKL is that the flow of gas beyond a Laval nozzle is not in vibrational equilibrium. If the lifetime of the CO_2 molecule at the upper laser level is longer than at the lower one, then the vibrational relaxation to the temperature of the flowing gas can lead to a temporary population inversion, and hence to an amplification of infrared (IR) radiation in a supersonic gas stream.

We investigate here the absorption of IR radiation from a CO_2 laser in a supersonic gas jet produced by escape of pre-heated gas from a slit to a vacuum. The stagnation temperature of the mixture of nitrogen and carbon dioxide is $T_0 = 1000°K$, the stagnation pressure is $P_0 = 4.2$ atm, the slit dimensions are 0.5 x 100 mm, and the observation coordinate, where the laser beam crosses the jet, is 1.6 cm away from the plane of the slit (Fig. 1). Conversion from the absorption coefficient for the vibrational component P(20) of the $(10^00) \rightarrow (00^01)$ transition to the populations of the vibrational levels is effect with account taken of 1) the gas temperature in the jet and the concentration of the CO_2 in the mixture, 2) the molecule distribution over the vibrational levels (the vibrational temperature was assumed to equal the gas temperature in the jet), 3) the joint action of