COULOMB EXCITATION OF SECOND 2^+ LEVELS IN EVEN-EVEN MEDIUM WEIGHT NUCLEI

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The energies of second 2^+ levels and the reduced probabilities for the corresponding transitions are determined for various even-even nuclei by measuring the coincidences of cascade γ rays.

THE Coulomb excitation of second 2^+ levels in even-even nuclei presents known difficulties. In the first place, these levels are rather high (generally higher than 1 MeV), and the cross section for Coulomb excitation falls off rapidly with increase in level energy. Second, the excitation cross section depends on the reduced transition probability B(E2). It is known that the B(E2) values for second 2^+ levels are very small, being orders of magnitude smaller than the B(E2) values for first 2^+ levels. The smallness of the cross section for the excitation of second levels prevents the observation of γ rays associated with the de-excitation of these levels, because of the background from nuclear reactions as well as the γ radiation emitted as a result of the Coulomb excitation of the first levels. In order to increase the sensitivity of the measurements, one must record the coincidences of cascade γ rays emitted in the de-excitation of the second 2^+ levels.

The Coulomb excitation of even-even isotopes of Ge, Se, Mo, Pd, and Te was investigated in our study. Targets made of these elements (in some cases targets enriched with specific isotopes) were irradiated with 8.5 MeV α particles and 36.41- and 53-MeV nitrogen ions which had been accelerated in the cyclotron of the Ioffe Physico-technical Institute of the U.S.S.R. Academy of Sciences. The γ radiation was detected by two scintillation counters with NaI(Tl) crystals used with a fast-slow coincidence circuit. The gamma coincidence spectrum was recorded by a 128-channel pulse-height analyzer. Since the intensity of charged particles in the extracted cyclotron beam varies with time, it is necessary to take accurate account of the contribution of accidental coincidences. To this end, a setup was used by which the spectrum of the true plus accidental coincidences and the spectrum of wholly accidental coincidences were simultaneously measured on two registers of the multi-channel analyzer.

The coincidence spectrum permits the determination of the energy of the cascade transitions and, consequently, both the energy ΔE of the second 2^+ levels and the reduced probabilities of the transitions to these levels. Since in our experiments only those γ rays associated with the de-excitation of second levels by a cascade transition were detected, it was only possible to determine the values ϵB(E2), where ϵ is the cascade transition fraction in de-excitation of the second level. To obtain B(E2) one must know the ratio of the probabilities for direct and cascade transitions from the second level. This ratio is known for a number of nuclei from data on β decay to the corresponding nuclei. In calculating B(E2), corrections were introduced for double Coulomb excitation. These corrections did not exceed 30% for the majority of the nuclei, but in the case of Ge^{72} and Te^{126} the contribution from double Coulomb excitation made up more than half of the observed γ-radiation yield.

It should be noted that no account was taken of

Nucleus	ΔE, keV	$\varepsilon B(E2)$, $e^2 \cdot 10^{50}$	$B(E2)$, $e^2 \cdot 10^{50}$	$\varepsilon B(E2)^*$, $e^2 \cdot 10^{50}$
Ge^{70}	1709±19	0.25±0.08	0.675	
Ge^{72}	1466±16	0.15±0.04	0.175	
Ge^{74}	1200±16	0.55±0.10	2.20	0.44±0.09
Se^{74}	1373±20	0.50±0.20		
Se^{76}	1230±15	0.65±0.18	1.17	0.76±0.15
Se^{78}	1306±15	0.78±0.15	1.40	0.55±0.11
Se^{80}	1441±17	0.94±0.26	1.94	0.97±0.20
Se^{82}	1486±20	0.78±0.18		
Mo^{94}	1577±20	0.50±0.15	0.545	
Mo^{96}	1524±19	1.09±0.30		
Mo^{98}	1491±20	1.38±0.35		
Mo^{100}	1047±14	1.35±0.35		1.75±0.26
Pd^{106}	1112±12	1.09±0.22	1.60	1.08±0.23
Pd^{108}	940±11	0.87±0.20		0.74±0.11
Pd^{110}	813±11	1.37±0.20		0.94±0.08
Te^{124}	1323±19	1.40±0.40	1.64	
Te^{126}	1457±17	0.47±0.15	0.50	
Te^{128}	1601±20	1.20±0.28		
Te^{130}	1765±20	1.12±0.23		

interference effects for lack of data concerning the phase difference. Corrections for the angular correlation of cascade γ rays turned out to be small (less than 5%) as a consequence of the close geometry of the experiment.

The results obtained are presented in the table. For comparison, the values of $\epsilon B(E2)^*$ obtained by Stelson and McGowan[1] in their investigation of Coulomb excitation using α particles are also given. It can be seen that the results are in agreement within the limits of measurement error. The values for the energies of the second 2^+ levels are also in agreement with known data. In the case of a number of nuclei (Se^{74}, Se^{82}, Mo^{96}, Mo^{98}, Te^{128}, and Te^{130}) the energies of the second 2^+ levels were not previously known.

[1] P. H. Stelson and F. K. McGowan, Phys. Rev. **121**, 209 (1961).

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