Letters to the Editor

STATISTICAL DELAY OF DISCHARGE IN NaCl *AND* KBr

M. A. MEL' NIKOV

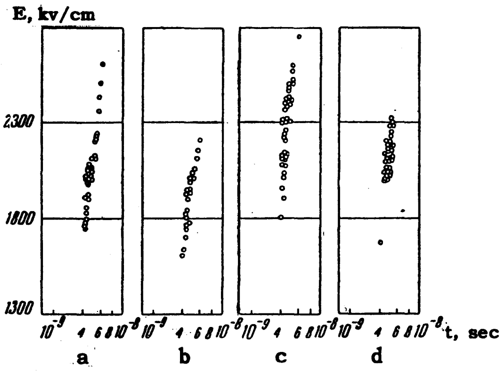
Tomsk Polytechnic Institute

Submitted to JETP editor June 9, 1958; resubmitted November 10, 1958

J. Exptl. Theoret. Phys. (U.S.S.R.) 36, 613-614 (February, 1959)

THE fact that x-ray treated and untreated crystals have the same value of pulse breakdown voltage[1,2] leads to the conclusion that an increase in the number of free electrons does not influence either the electric strength or the delay time t_d of the discharge, and that there is no statistical delay time t_{st}. In NaCl exposed for 10^{-8} sec, t_{st} is almost zero.[3,4] In mica and glass, the statistical delay is either zero or less than 10^{-8} sec.[5] According to reference 6, $t_{st} > 10^{-8}$ in KCl, but the procedure employed in this reference, whereby the specimen was exposed to multiple pulses, was not faultless. Thus, at exposures of 10^{-8} sec and longer, there is no statistical delay in solid dielectrics.

We have developed a procedure for obtaining high-voltage pulses (up to 27 kv) with wavefronts of 10^{-9} sec, and for recording these pulses with a pulsed[7] cathode-ray oscillograph. We attempted to estimate t_{st} with the aid of this procedure of NaCl and KBr crystals. The breakdown was produced between a hemisphere and a plane (spaced $100\,\mu$ at the thinnest point), with the front of a single pulse, applied for intervals ranging from 4 to 6 millimicroseconds. The specimens were either untreated or previously treated with x-rays for four hours and illuminated during the time of breakdown. The diagram shows the dependence of



Dielectric	E_b, kv/cm	t_d	ΔE		Δt_d	
		10^{-9} sec	kv/cm	%	10^{-9} sec	%
Untreated NaCl	2420	2.7				
X-ray treated NaCl	2130	2.2	290	12	0.5	18.5
Untreated Kbr	2570	2.85				
X-ray treated Kbr	2280	2.38	290	11.6	0.47	16.5

the electric strength E_b on the time prior to breakdown of the untreated and x-ray treated specimens of NaCl and KBr. The table lists the values of the strength for a breakdown probability $\psi = 90\%$, the discharge delay time t_d, the reduction in strength ΔE_b, and the reduction in the discharge delay time Δt_d for x-ray treated and untreated specimens. The value of t_d was determined by the Vorb'ev procedure.[3] The static strength, used to determine t_d, was assumed to be the same for treated and untreated specimens, namely the value of E_b of untreated specimens when the voltage was applied for 10^{-6} sec, before space charge could manifest itself.

To ascertain whether the difference in the values of E_b and t_d for treated and untreated specimens lies within the experimental error, we analyzed the possible errors. A detailed analysis of the errors that arise in experiments similar to ours was made in reference 3. We give a brief analysis of the errors in our experiments. We measured the thickness of the specimen with the IZV-1 instrument, which reads 1μ per scale division, and in which the relative error is $a_1 = 1\%$ for both treated and untreated specimens. The errors a_2 and a_3, which can arise in the oscillographic determination of the amplitude of the voltage pulse and of the time prior to breakdown, do not exceed 2% and 5% respectively. The divider and tube were calibrated with measuring spheres. However, since we used the same calibration curve for both x-ray treated and untreated specimens, the error in the calibration of the tube is automatically allowed for in the calibration curve. Errors may result from distortion in the oscillograms. At a tube accelerating voltage of 42 kv the electron velocity was 1.22×10^{10} cm/sec and the time of flight in the deflecting field was 3.28×10^{-10} sec. The reduction in the amplitude, allowing from the effect of the electron time of flight between deflecting plates, is not more than 0.2%. The distortion due to the asymmetry of the potential of the deflecting plates (cf. reference 8) does not affect the results of the measurements.

Thus, the error in the pulse amplitude amounted to $a_1 + a_2 = 1 + 2 = 3\%$. It follows therefore that the difference in the values of E_b and t_d for untreated and treated specimens does not lie within the experimental error and probably indicates the presence of a statistical delay in the discharge of untreated NaCl and KBr specimens. If $t_{st} = 0$ for treated specimens, the difference in the discharge delay time will be the statistical delay time for untreated specimens, with values 5×10^{-10} sec for NaCl and 4.7×10^{-10} sec for KBr. If $t_{st} \neq 0$ for the treated specimens, the differences in the delay time are the differences in the statistical delay times of the discharge in untreated and x-ray treated specimens of NaCl and KBr.

The author takes this opportunity to thank Prof. A. A. Vorob'ev for guiding this research.

[1] A. F. Walther and L. D. Inge, Dokl. Akad. Nauk SSSR **2**, 65 (1934).

[2] A. Walther and L. Inge, Arch. Elektrotechn. **28**, 72 (1934).

[3] G. A. Vorob'ev, Dissertation, Tomsk Polytechn. Inst., 1956.

[4] K. K. Sonchik, **Изв. Высшей школы СССР, Физика** (News of the Higher Schools, Phys. Ser.) No. 4, 73 (1958).

[5] E. A. Konorova, J. Exptl. Theoret. Phys. (U.S.S.R.) **32**, 603 (1957), Soviet Phys. JETP **5**, 497 (1957).

[6] Kawamura, Ohkira, and Kichi, J. Phys. Soc. Japan **9**, 541 (1954).

[7] G. A. Vorob'ev, **Изв. Высшей школы СССР, Физика** (News of the Higher Schools, Phys. Ser.) No. 4, 174 (1958).

[8] Voznesenskiĭ, Korotkikh, Chernetskiĭ, and Koporskiĭ, Usp. Fiz. Nauk **62**, 4, 497 (1957).

Translated by J. G. Adashko
101

ON THE QUESTION OF COLLECTIVE EFFECTS IN LIGHT NUCLEI

V. V. BALASHOV and A. F. TULINOV

Institute of Nuclear Physics, Moscow State University

Submitted to JETP editor June 27, 1958

J. Exptl. Theoret. Phys. (U.S.S.R.) **36**, 615-616 (February, 1959)

In the region of light nuclei, the shell model gives good agreement with experiment for the magnetic moments and the probabilities of the magnetic dipole γ transitions. On the other hand, there is no such agreement for the probabilities of the E2 transitions and the electric quadrupole moments (cf. the table; the energy of the levels, E, is given in Mev).

The values for τ_{theor} for the transitions in C^{12} taken from the paper of Kurath,[5] corrected for the value $\langle r^2 \rangle = 5.7 \times 10^{-26}$ cm^2 obtained by Hofstadter.[6] It is seen from the table that in all three cases the measured transition probability is higher than the calculated one. The analysis of the relative intensities of the E2 and M1 transitions leads to the same result.[5,7]

If we further consider that the measured nuclear quadrupole moments lie well above those calculated with the shell model,[8] we are driven to the conclusion that the shell model always gives too low values for the corresponding matrix elements.

It is believed that this situation is connected with the collective motion of the nucleons in the nucleus. This effect was accounted for in the nucleus O^{17} by introducing an additional effective nucleon charge $e' = \alpha e$, which is connected with the excitation of collective quadrupole oscillations in the nucleus.[9] α was found to be ≈ 0.6. We note that better agreement with experiment is indeed obtained by using approximately this value for the effective charge in the calculation of the matrix elements for the transitions in the nuclei C^{12} and B^{10}. However, the concept of an effective charge is closely connected with the formalism of the unified nuclear model of Bohr and Mottelson,[10] whose applicability to light nuclei is doubtful. In this sense the use of an effective charge in the region of light nuclei corresponds to the formal introduction of additional parameters; the question of the role of collective effects in E2 transitions in light nuclei, therefore, remains open.

In view of this it is of interest to consider the collective effects in the nucleus in a general way, independently of the specific mechanism of the collective intensification of the electric quadrupole transitions and, hence, of the introduction of any additional parameters.

In the absence of the single-particle operator, the operator for the quadrupole transition connected with the collective motion contains, owing to the charge independence of nuclear forces, only the scalar component of the isotopic spin. (In the framework of the unified nuclear model this follows immediately from relation (7.12) of refer-

Nucleus	Transition $E(J, T) \to E(J', T')$	τ, experiment	τ, theory	
			$L-S$	$j-j$
C^{12}	$4.43\ (2.0) \to 0\ (0.0)$	$5.25 \cdot 10^{-14}$ sec [1]	$1.8 \cdot 10^{-13}$ sec	$4.2 \cdot 10^{-12}$ sec
B^{10}	$0.72\ (1.0) \to 0\ (3.0)$	$1.05 \cdot 10^{-9}$ sec [2]	∞	$4.5 \cdot 10^{-9}$ sec
Be^{10}	$3.37\ (2.1) \to 0\ (0.1)$	$< 8 \cdot 10^{-14}$ sec [3]	$1.4 \cdot 10^{-13}$ sec	∞ [4]