my conclusion that in the absence of a limitation on the discharge current the breakdown of liquids takes place by a single avalanche process without a leader stage. In the above remarks this conclusion was questioned, and it was asserted that, independently of such limitations, the breakdown process must always be of the leader type. In support of his views G. A. Vorob'ev quoted an American article[3] in which, however, something quite to the contrary is stated.

It should be noted that in my article the absence of a leader stage was mentioned in the sense that the development of the breakdown process takes place gradually, without interruptions in time. For such relatively small interelectrode gaps as a few centimeters it appeared to me useful to speak of an avalanche stage which then goes over into streamer stage. In the case of an uninterrupted development of the process a streamer, or streamers traveling in opposite directions, short the electrodes, the principal discharge is formed and the breakdown ends in the formation of a highly conducting bridge. I used the concept of the leader stage in those cases when the process of the development of the breakdown was discontinuous in time.

In my opinion it is shown sufficiently clearly in reference 2 and more particularly in reference 4 that specifically in the absence of resistors R to limit the current, the breakdown of certain liquid dielectrics takes place without a leader stage in the sense indicated above.

In investigating the pre-breakdown processes in liquids one could come to the conclusion[2] that the development of the breakdown process in some cases takes place unexpectedly or suddenly. The breakdown begins to form progressively without an appreciable increase in current right up to the moment of the "collapse" of voltage. The process itself of the formation of breakdown naturally takes a certain length of time. This time has been determined by me in certain cases[4].

In what circumstances then does a discontinuous development of the breakdown or a leader process occur? On the basis of experimental data described in references 2 and 4 it is possible to assert that when the current in the discharge channel is limited, the temperature of the latter does not rise sufficiently so that the intense thermal ionization and photoionization can make the discharge channel of the first leader highly conducting. There are reasons to believe that this process of formation of a highly conducting bridge (broadening of the channel) grows in a cumulative fashion under favorable circumstances. As the degree of ionization increases, the current flowing through the channel also increases. The temperature of the latter increases in the meantime, and consequently the intensity of thermal ionization and photoionization increases, the broadening of the channel increases still further, etc. Of course it is also necessary to take into account here the processes which oppose the development of the breakdown, such as the capture by the molecules of the liquid of the electrons in the streamer, recombination, excitation of electrons in atoms and molecules of the liquid, radiation, heat being conducted away, collisions of the second kind, etc. When the discharge current is limited, the broadening of the channel must cease at a certain stage, and these opposing processes assume a dominant influence: the discharge stops.

It should be noted that, as experiments have shown, during the statistical delay time, sometimes even without the inclusion of a limiting resistor, the progressive development of the discharge is suppressed by the opposing processes in the stage of formation of avalanches or even of small streamers. However, this takes place only in the case when the applied voltage is somewhat lower than the breakdown value. Therefore such processes should not be confused with the progressive development of the breakdown.

[1] G. A. Vorob'ev, J. Exper. Theoret. Phys. USSR **27**, 764 (1954)

[2] I. E. Balygin, J. Exper. Theoret. Phys. USSR **25**, 736 (1953).

[3] T. W. Liao, J. G. Anderson, Trans. AIEE **72**, 641 (1953).

[4] I. F. Balygin, J. Exper. Theoret. Phys. USSR **24**, 338 (1954).

Translated by G. M. Volkoff
264

Photoelectric Recording of Spectra of Combination (Raman) Scattering of Powdery Materials

IA. S. BABOVICH AND V. M. PIVOVAROV

(Submitted to JETP editor March 1, 1955)
J. Exper. Theoret. Phys. USSR **29**, 696-697
(November, 1955)

IN the solution of a number of applied problems, and also in the investigation of certain basic problems, such as the question of the influence of the aggregate state on the character of the spectrum of combination (Raman) scattering, one frequently deals with powdered material. Digressing

from the specific method (amply described in the literature [1-3]) for obtaining the spectra from similar objects, we note that there is no indication in any of the well-known reference works that photoelectric recording of the spectra has been applied. A photographic plate has always served as the energy detector. However, a direct comparison with the photographic plate shows the advantages of the photoelectric detector, particularly in its superior presentation of weak lines in a continuous background[4,5], so that the expediency of using the photoelectric method of recording should not require comment.

The results of the experiments on photoelectric recording of spectra from certain powdery materials--napthalene and a series of nitro derivatives of benzene--are given in this letter. The method of diffuse reflection was used to obtain the spectra[3]. Recording of the spectra was obtained by the photoelectric arrangement described earlier[5]. The spectra were excited by a specially prepared, high power, low pressure mercury lamp. Such a lamp, being practically free from a continuous background spectrum, considerably simplified the solution of the problem undertaken.

The lamp was constructed of molybdenum glass in the form of a spiral with three loops (inner diameter about 100 mm). Water cooled liquid mercury served as the cathode. An auxiliary mercury anode was located near the cathode. The operating anode was a molybdenum tube. The lamp was fed from a 120 volt constant current circuit. Ignition was produced by a high voltage pulse (10-11 kv) after a preliminary heating by an electric oven in the presence of the arc cathode--auxiliary anode. The operating current of the lamp was 15-25 amp. Under these conditions, the potential drop across the lamp was approximately 70-100 volts. The lamp was installed in an illuminator, which was evacuated by a procedure in which cold phenamine was blown through it. It was coated with magnesium oxide to increase the light yield.

The first experiments showed that, in spite of a strong reflection of light from the faces of the crystals of the substance and from the vessel of tapered conical glass, the continuous background spectrum was very weak. It was not necessary to insert a background absorbing filter in the primary beam; it was necessary only to use a filter which absorbed the short wavelength radiation. A vessel with an aqueous solution of potassium ferricyanide (red, molarity approximately 0.003 in a layer 8 mm thick) was inserted in the secondary beam just in front of the inlet slit of the monochromator in order to weaken the exciting line $\lambda = 4358$ Å; a blue glass filter BG-25 (located in the same position) was used to attenuate the long wave portion of the spectrum. Our particular monochromator, constructed on the principle of

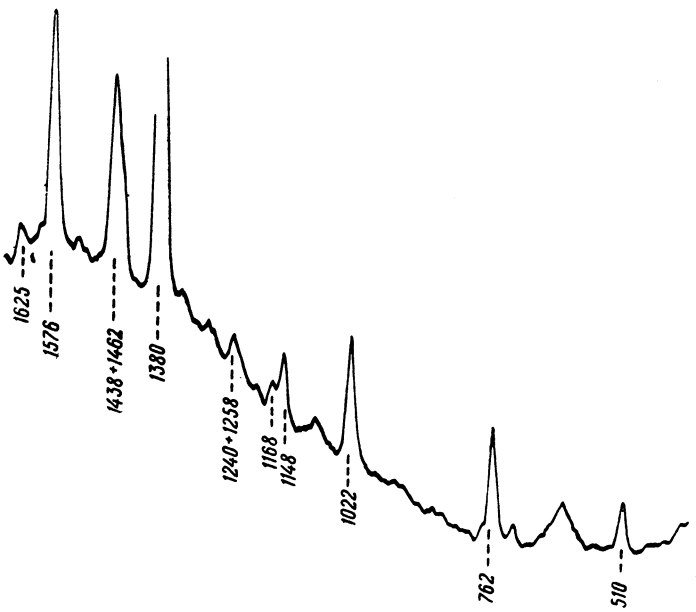

FIG. 1. Spectrum of combination scattering of powdery naphthalene. Voltage source FEU, 910 volts. The width of inlet and outlet slits was 0.2 mm. Frequencies (in cm^{-1}) are shown for certain lines of combination scattering.

the diffraction grating, made the use of the latter filter necessary; we demonstrated that false lines (ghosts) appear in the spectrum as a result of intense green and orange lines of the mercury lamp falling on the light apparatus. Although the intensity of the ghosts made up only 0.002-0.003% of the intensity of the basic lines, nevertheless, they appeared and interfered with the measurement, because of the very great sensitivity of our apparatus. In the course of thus weakening the undesirable radiations by means of filters, the useful radiation was also attenuated, by about a factor of five. However, this did not prevent the obtaining of a complete, high quality record.

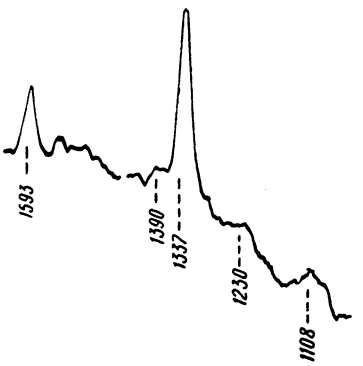

FIG. 2. Spectrum of combination scattering of powdery paranitrotoluene. Supply voltage FEU, 910 volts. Width of inlet slit, 0.7 mm, outlet slit, 0.2 mm. Frequencies (in cm^{-1}) are shown for certain lines of combination scattering.

For illustration, we have reproduced in Figs. 1 and 2 the records of the spectra of naphthalene and paranitrotoluene, excited by the blue line of mercury, $\lambda = 4358$ Å. The second substance, being finely crystalline and slightly transparent, absorbed the exciting line rather strongly, and made it difficult to obtain a spectrum. Comparison of a series of such records shows excellent reproducibility. The intensity distribution over the spectrum is altered, however, a consequence of the use of filters.

We have thus shown the possibility of the direct recording of the spectra of combination scattering from powdery materials. It would be appropriate in any further investigation of powdery materials to use a dual monochromator for the purpose of increasing the luminosity of the apparatus and for obtaining spectra with undistorted intensity distribution.

[1] K. Kol'raush, *Spectra of Combination Scattering*, IIL, 1952.

[2] G. S. Landsberg and F. S. Baryshanskaia, Izv. Akad. Nauk SSSR, Ser. Fiz. **10**, 509 (1946).

[3] Ia. S. Bobovich and M. M. Pakhomova, Dokl. Akad. Nauk SSSR **92**, 947 (1953).

[4] M. M. Sushchinskii, J. Exper. Theoret. Phys. USSR **20**, 304 (1950).

[5] Ia. S. Bobovich and D. B. Gurevich, J. Exper. Theoret. Phys. USSR **27**, 318 (1954).

Translated by J. M. Coogan
256

Meson Corrections in the Theory of Beta Decay

S. S. GERSHTEIN AND IA. B. ZEL'DOVICH

(Submitted to JETP editor June 8, 1955)
J. Exper. Theoret. Phys. USSR **29**, 698-699
(November, 1955)

IN a recent note, Finkelstein and Moszkowski[1] discuss the effect of strong coupling between nucleons and pions on the beta decay of nucleons.

Using the language of Feynman diagrams these authors[1] consider, in addition to the fundamental process (Fig. 1 *a*), another process involving the virtual emission of one π^0 meson (Fig. 1 *b*). The calculation is carried out on the basis of the hypotheses under which Chew[2] discusses nuclear forces and the creation and scattering of mesons, and Friedman[3] discusses the anomalous magnetic moment of the nucleon: the nucleon is assumed to be infinitely heavy, and integrals over the momenta of virtual mesons are cut off at a specified value p_{max}. From comparison with experiment it is found that p_{max} is close to Mc. A system with charge symmetry is considered so that the operator τ_3 enters into the expression for the coupling of nucleons to π^0.

Our notation will be very similar to that of Sachs[4]. Let P_1 be the probability that there is a virtual π^0 meson around the nucleon, compared with the probability that the nucleon is "bare", i.e., has no mesons around it*. The beta-decay coupling constants of a bare nucleon are denoted