LIMITS OF VALIDITY OF THE SPECIAL THEORY OF RELATIVITY BASED ON EXPERIMENTAL TESTING OF THE NEUTRALITY OF ATOMS

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The outcome of Mishelson-Morly experiments has implied the "fall" of classical nonrelativistic physics and, also, represented the first experimental data in favour of later special theory of relativity. The later discoveries of a series of experimental effects, predicted either by special theory of relativity directly or by other theories based on special theory of relativity, have proved the high degree of experimental confirmation of the special theory of relativity. However, the most illustrative way to establish an experimental limit up to which a theory is confirmed seems to be search for an efect stricktly forbidden by that theory. Such situation arises in the application of special theory of relativity in electrodynamics, which results in a forbidness of charge dependance on velocity. Namely, if we write

$$q(v) = q(o) \cdot [1 + \alpha(v/c)^2] \quad , \qquad (1)$$

in order to have charge q independent from velocity v, the special theory of relativity demands $\alpha = 0$.

Chiu and Hoffmann[1] have found out a way to determine the experimental limit of coefficient from the experimental data on the neutrality of atoms and molecules. Neglecting relatively slow motion of atomic nucleus and taking into account only the motion of atomic electrons, the charge of atom becomes

$$\delta q = \alpha \cdot e \sum_{i=1}^{Z} (v_i/c)^2 \qquad (2)$$

and, in order to find the limit on coefficient α, one has to find the experimental limit of δq, while the sum appearing in preceeding formula is easily estimated from simple atomic models.

Interpretation of experiments, in which the neutrality of atoms is tested, includes also the definition $\delta q = e \cdot y$ and it is customary then to give the limit on y.

The experiments made by different authors[2] could be grouped in three groups.

First group includes the experiments aimed to determine the deflection of beams made of (neutral) atoms or molecules in electric field. In all experiments, made with beams of H_2, D_2, CsF, CsJ, KF, K and Cs, no deflection is found out of experimental errors, which, therefore, determine the upper limits of y. The lowest experimental error is achieved in the experiment mada with (neutral) Cs atomic beam and using this errors one may determine $y \leq 6 \times 10^{-17}$. This implies the upper limit for coefficient from (1) to be $\alpha \leq 5 \times 10^{-17}$.

In second group of experiments, two metalic mutually isolated containers (smaller one inside the larger one) are employed as an electric capacitor and a (neutral) gas efflux from the inner container is used in order to measure if this efflux produced any electric potential difference of two containers. Assuming the (neutral) gas atoms or molecules are charged by $\delta q = e \cdot y$ per atom, one tries to determine y. In all experiments, performed with CO_2, H_2, He, N_2 and A, the neutrality of atoms is confirmed and the experimental errors determine the upper limit of y. The lowest experimental limit is obtained with efflux of A, in which case obtained $y \leq 4 \times 10^{-20}$ means also $\alpha \leq 5 \times 10^{-19}$.

Third group includes Milliken-type experiments which yielded $y < 6 \times 10^{-16}$ meaning $\alpha \leq 1 \times 10^{-13}$ for oil drops. However, we include here also the modern experiments with levitation of metalic particles in magnitc of electric fields, which were interpreted always only with respect to the search for quarks. The cleanest of them, made by Blend et al., with tungsten (W) particles could be interpreted as yielding $y \leq 3 \times 10^{-14}$ meaning $\alpha \leq 1 \times 10^{-14}$. Other experiments made with larger metalic particles yield even lower limits: the most dubious one, made by LaRue et al. (from which authors think they detected a quark with -e/3) might, perhaps, be interpreted as giving $y \leq 4 \times 10^{-21}$ and, correspondingly, $\alpha \leq 6 \times 10^{-21}$.

We report here, also, the results of two of our own experiments, both yielding the limits for y and α.

First of them employs an essential modification of gas efflux method. The modification consists in introducing about 10 liters of the liquid N_2 inside the inner container before every experimental run and evaporating this great quantity of N_2 molecules during N_2 gas efflux period. From 26 experimental runs, we were able to extract the limit $y \leq 4 \times 10^{-22}$, leading to $\alpha \leq 1.2 \times 10^{-20}$.

Second experiment used the gravitational fall of a heavy metalic ball inside two colinear mutually isolated containers, constituting an electric capacitor. The transfer of metalic ball from one to other container should produce an electric potential difference among them, if metalic atoms are not neutral. Essentially null-result was obtained, with experimental errors limiting $y \leq 1 \times 10^{-19}$ and, correspondingly, $\alpha < 5 \times 10^{-19}$.

Taking into account all experiments yielding the mentioned limits on neutrality of atoms, it is obvious that the independance of charge from velocity is confirmed up to a very high degree of credibility. Therefore, one can conclude that the special theory of relativity is exact at least up to these limits.

REFERENCES:

[1] H.Y. Chiu and W.F. Hoffmann in Gravitation and Relativity, W.A. Benjamin, Inc. (1964)

[2] V.W. Hughes, ibid.