Further limits on the stability against elastic tachyonic decay

A. Ljubičić, Ž. Pavlović, and K. Pisk
Institute Rudjer Bošković, Zagreb, Yugoslavia

B. A. Logan
Department of Physics, University of Ottawa, Ottawa, Canada
(Received 11 November 1974)

An experimental arrangement involving a metal oxide cathode and a windowless-channel electron multiplier has been used to place a lower limit on the lifetime of elastic tachyonic decay. Our system was sensitive to tachyons with proper masses greater than 1.1 keV and we obtain a lower limit of 4.6×10^{13} years for the mean life. The result gives a lower limit for the lifetime, in the tachyon proper-mass range of about 1–10 keV, which is higher than that obtained previously.

The possible existence of faster-than-light particles (tachyons) has aroused considerable interest in recent years and a new experimental result,[1] which can be interpreted in terms of tachyons existing in cosmic-ray showers, will probably stimulate further research.

If tachyons do exist, elastic tachyonic decays are possible and a particle of mass m can decay into itself and a neutral tachyon.[2] When the emitted tachyon has a proper mass $i\mu$ (where μ is called the "liberty mass"[3]) then, in elastic tachyonic decay, the particle can gain an energy $+\mu^2/2m$ and the tachyon has an energy $-\mu^2/2m$. The existence of tachyons can be investigated by observing apparent spontaneous acquisitions of energy by a particle and interpreting these acquisitions in terms of possible tachyonic decays.

This approach has been used to place lower limits on the lifetimes of various elementary particles against elastic tachyonic decay. Danburg and Kalbfleisch[3] investigated proton recoils in a bubble chamber and placed lower limits on the lifetimes for the tachyonic decay of free protons for μ values above about 100 MeV. These authors also analyzed a variety of existing data[4-7] and placed lower limits on the lifetimes for the elastic tachyonic decay of free protons, bound nucleons, and atomically bound electrons over a wide range of μ values. Ramana Murthy,[8] from considerations of the background counting rate in shielded Geiger-Müller counters, has placed a lower limit of 2×10^{15} years for elastic electron tachyonic decay for μ values above 10 keV. No direct experimental investigations have been reported for μ values below 10 keV. However, it is possible to analyze the heat flow emanating from the earth and, by assuming that the heat energy is produced via elastic electron tachyonic decay, to place limits on the lifetime for a decay.[2] This analysis can be applied for any μ value.

This work reports a measurement of the lower limit for elastic electron tachyonic decay for μ values down to 1.1 keV. The principle of the method is similar to that of Ramana Murthy,[8] who used Geiger-Müller counters containing a mixture of argon and ethyl ether. The average binding energy of the outer-shell electrons was about 100 eV, and tachyonic decays which satisfied $\mu^2/2m > 100$ eV could produce ionization in the counter. If it is assumed that all the background is due to elastic electron tachyonic decays measurements of the background counting rate, allow a lower limit to be placed on the lifetime of elastic electron tachyonic decays for μ values above 10 keV. In our experimental arrangement solid-state materials have been used and the binding energy of the valence electrons (the work function of the material) is two orders of magnitude below the average binding energy of the electrons in the Geiger-Müller counter and this allows the elastic electron tachyonic decay to be investigated for lower values of μ.

A thin layer of lead oxide ($PbO + Pb_2O_3$) was deposited onto a glass backing. The work function of this compound is 1.2 eV. The sample was placed in front of a 0.8-cm^2 circular aperture of a windowless-channel electron multiplier (model SEM-4219). The effective thickness of the lead oxide was measured to be 1.5 μ. The number of free electrons in the valence bands of such materials is about $10^{22}/cm^3$, and it was estimated that approximately 1.2×10^{18} electrons were available for detection if they acquired the necessary escape energy of 1.2 eV.

An accelerating grid ensured that electrons leaving the sample with negligible kinetic energy were accelerated onto the channeltron conus with a kinetic energy in excess of 100 eV. The channeltron was operated in the saturation mode and the efficiency of the system was 0.8 for electrons with kinetic energies above 100 eV. Several precautions were taken to minimize noise. The power

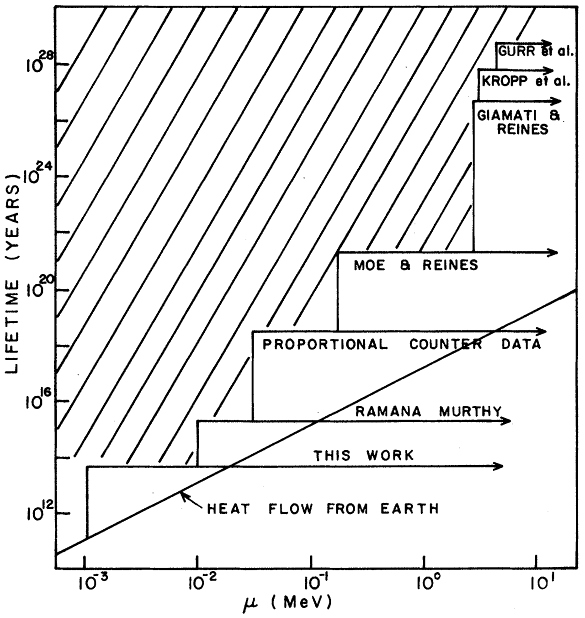

FIG. 1. Lifetime (mean life) for the elastic tachyonic decay of bound electrons as a function of the tachyon liberty mass μ. The hatched area is the allowed range of lifetimes.

supply was carefully filtered and a floating ground arrangement was used. Electrostatic and magnetic shields were used, precautions were taken against field-emission effects, and the sample was cooled with liquid nitrogen. Another nearby channeltron, which used the same electrical power supply and which was in the same thermal environment, was operated in an anticoincidence mode in order to minimize spurious effects. After taking into account the appropriate corrections the rate of electron emission from the lead oxide sample was less than 3 counts/hour. If this emission is assumed to be due to tachyonic decays a lower limit of 4.6×10^{13} years is obtained for the mean life of the elastic electron tachyonic decay for μ values above 1.1 keV.

Our result can be compared with previous work. The relevant data are summarized in Fig. 1. For μ values below 10 keV the only other data were obtained from the analysis of the heat flow emanating from the earth. At a μ value of 1.1 keV our result gives a lower limit on the mean life which is three orders of magnitude higher than that obtained from the heat-flow analysis. For a μ value of 10 keV our result is approximately the same as that obtained from the heat-flow analysis. Consequently, our result gives new lower limits on the lifetimes for elastic electron tachyonic decay for μ values in the range 1.1–10 keV.

It has also been noted that available data on the background counting rates in proportional counters[9] can allow new lower limits to be placed on the mean life of elastic electron tachyonic decay for μ values above 33 keV. This new limit is included in Fig. 1.

It is realized that the reinterpretation principle[10] allows us to view the negative-energy tachyons going forward in time as positive-energy tachyons going backward in time. As a consequence of this the emission of a negative-energy tachyon could be interpreted as the absorption of a positive-energy tachyon. Recently, Recami and Mignani,[11] postulating that physical signals are only transmitted by positive-energy objects, claimed that all spontaneous acquisitions of energy which are produced by tachyonic interactions must be produced by the absorption of positive-energy tachyons or antitachyons. If one accepts this view the number of events observed in the recoil experiments depends on the electron-tachyon coupling constant and on the flux of tachyons with energies above $\mu^2/2m$. Although the electron-tachyon coupling constant is not known, the nonobservation of tachyonic interactions implies that it is small. Similarly, the tachyon flux is also unknown, but as tachyonic interactions seem to be weak it would seem reasonable to assume an isotropic flux distribution in our environment. Our result can be interpreted as a measure of the total probability for tachyonic interactions (including the electron-tachyon coupling constant *and* the tachyon flux) in our environment for tachyons with energies above 1.2 eV.

[1]R. W. Clay and P. C. Crouch, Nature 248, 28 (1974).
[2]G. Feinberg, Phys. Rev. 159, 1089 (1967).
[3]J. S. Danburg and R. Kalbfleisch, Phys. Rev. D 5, 1575 (1972).
[4]M. K. Moe and F. Reines, Phys. Rev. 140, B992 (1965).
[5]C. C. Giamati and F. Reines, Phys. Rev. 126, 2178 (1962).
[6]W. R. Kropp, Jr. and F. Reines, Phys. Rev. 137, B740 (1965).
[7]H. S. Gurr, W. R. Kropp, F. Reines, and B. Meyer, Phys. Rev. 158, 1321 (1967).
[8]P. V. Ramana Murthy, Phys. Rev. D 7, 2252 (1973).
[9]D. E. Watt and D. Ramsden, *High Sensitivity Counting Techniques* (Pergamon, New York, 1964), Chap. 6.
[10]O. M. P. Bilaniuk, V. K. Deshpande, and E. C. G. Sudarshan, Am. J. Phys. 30, 718 (1962).
[11]E. Recami and R. Mignani, Riv. Nuovo Cimento 4, 209 (1974).