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BETA DECAY EMITS NO NEUTRINO

CHAN RASJID KAH CHEW

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ABSTRACT. The 1927 Ellis-Wooster calorimetry experiment was an attempt to resolve the controversy over the continuous energy distribution spectrum of beta decay. A Radium E source was placed within a calorimeter in order to capture and measure the heat generated by beta decay. If the beta decay energy is assumed to be quantized, the captured heat energy should match the maximum spectrum energy of 1.05 MeV if the calorimeter captured all the disintegration energy. The result of the experiment gave the captured average heat of beta decay to be 350,000 eV instead of the expected 1.05 MeV. The 350,000 eV was accepted to be a match to the average spectrum energy of 390,000 eV. The experiment indicated some energy escaped the Ellis-Wooster calorimeter - thus the notion of "*missing energy*". The thesis of this paper is that the conclusion of the Ellis-Wooster experiment depends on whether the heat of calorimetry is consistent with relativistic kinetic energy or with classical kinetic energy. The spectrum energy used by the experiment was based on relativistic energy. If the values are converted to classical energy, the the maximum spectrum energy would only be 230,000 eV and the average 120,000 eV. The captured heat was much greater than the average of 120,000 eV. This reinterpretation would dismiss the notion of any missing energy in the experiment. The question of whether there was any missing energy is related to whether physical reality is consistent with special relativity or with Newtonian mechanics. The basis upon which Wolfgang Pauli proposed his 1930 neutrino hypothesis was the conclusion of the 1927 Ellis-Wooster experiment which supposedly supported the idea of "*missing energy*". The neutrino and the current neutrino physics would remain if special relativity is found to be the correct mechanics representing the physical world. On the other hand, if Newtonian mechanics is found to be correct, then all of neutrino physics would have to be dismissed. The one experiment that could decide on the issue is to determine the maximum speed with which beta particles are ejected in beta decay using the direct time-of-flight method. If Newtonian mechanics is correct, then there would be beta particles found to go beyond the speed of light; otherwise, it would be experimental evidence supporting special relativity. The result of this experiment would settle unequivocally the question concerning the nature of physical reality. But to date, this experiment has not been carried out.

Key words and phrases. neutrino, Ellis Wooster experiment, alpha decay, beta decay, continuous energy spectrum, Einstein, relativity, special relativity, relativistic mechanics, Lorentz force law, Bucherer experiment .

1. Introduction

Radioactivity was discovered by Henri Becquerel in 1896. Soon after, this new phenomenon of matter spontaneously emitting mysterious radiations caught the attention of almost the entire physics academia; many physicists of note, including Rutherford, Niels Bohr and the Curies, got involved. The new radiations were later grouped as alpha, beta and gamma rays. Alpha rays were found to be the nucleus of the helium atom, beta rays to be electrons and the gamma rays to be electromagnetic radiations similar to light but much more penetrating. Radioactivity also caused nuclear transformation from one species of element to another different species. It was beta rays from beta decay that caused the greatest controversies spanning years from 1910 to early 1930s.

It was natural that attention was given to examine the energies of disintegration of the radioactive elements. What was found was that alpha decay emits alpha particles with a distinct discrete energy for an element; the energy, though, would be dependent on the species of the decay element. This was rather expected as decaying atoms should be all similar and when they transformed to another, but same species, the amount of energy released should be quantized; it would result in the alpha-particle being ejected with a fixed amount of energy as long as no energy loss occurred.

A great surprise came when the decay energies of the beta rays were measured. Unlike alpha decay, the beta electrons were not ejected with a distinct discrete energy; instead the electrons were found to be ejected with a continuous energy distribution spectrum. A typical example is the spectrum of Radium E (Bismuth-210) as provided by the Ellis-Wooster experiment of 1927 (figure 1); the energies ranged from 40,000 eV to a distinct cutoff maximum of 1.05 MeV. It was James Chadwick (who discovered the neutron in 1932) who did experiments in 1914 which confirmed the continuous energy spectrum of beta decay. Lise Meitner explained that the continuous spectrum was a result of *secondary effects* that caused the ejected electrons to lose energy in their passage leaving the decaying atoms. Three main causes were suggested: 1) Compton scattering, 2) interference from intermediate gamma rays, 3)scattering by the planetary electrons. Ellis rejected all three explanations.

2. Ellis-Wooster 1927 Experiment

The controversy surrounding the continuous energy spectrum of beta decay had deep implications as there even was a suggestion by Niels Bohr that the energy conservation law may not apply to beta decay atoms individually, but only statistically within the nucleus. It

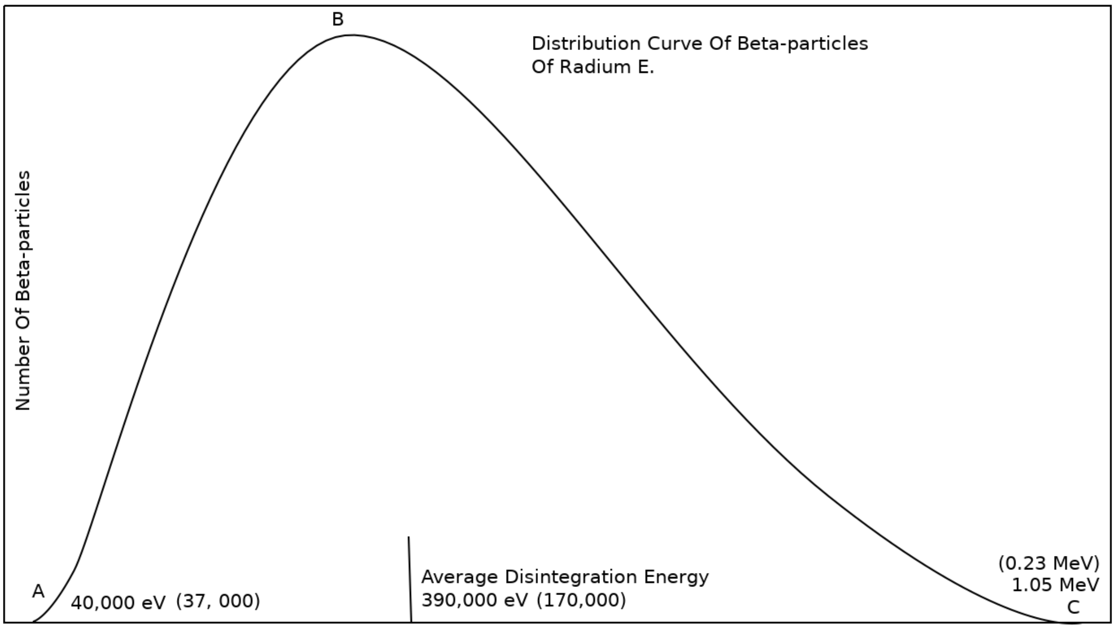

FIGURE 1. Energy is relativistic; equivalent classical values within brackets

was a most urgent matter to resolve the controversy. C.D.Ellis, a lecturer with the University of Cambridge and W.A. Wooster, Charles Abercrombie Smith Student of Perterhouse, Cambridge, conducted a calorimetric experiment [1] in an attempt to put to rest the controversy. They reasoned that a calorimetric measurement of the heat produced from beta decay should settle the controversy. If the beta decay were to disintegrate with a distinct quantized amount of energy, enclosing the beta decay source within a calorimeter should produce the average heat generated per disintegration equal to the maximum spectrum energy of 1.05 MeV; this would imply some *secondary effects* to be the cause of lost of energies of the emitted electrons. On the other hand, if the heat captured should be equal to the average energies of the spectrum of 390,000 eV, then the idea of *secondary effects* would be untenable; the continuous energy spectrum represented fully the energies of disintegration of beta decay. They acknowledged the great difficulties such an experiment would involved, but they were confident as they only needed an accuracy to distinguish between heat energy of 40,000 eV and 1.05 MeV, almost a three times factor difference.

As the calorimetric heat would have to be compared to the Radium E energy spectrum in order to draw a conclusion on the experiment, it is necessary to know how the spectrum of figure (1) was obtained. It was obtained from an experiment by a Mr. Madgwick carried out at the Cavendish laboratory: "*The B-ray emission of Radium E can be* *analyzed by means of a magnetic field and the intensities of the rays of various energies determined by means of an ionization chamber*". Ellis and Wooster also commented that "*...there can be no doubt about the substantive correctness of the curve...*".

The only technique to measure the energy of electrons directly is calorimetry where the electrons are captured in matter and the heat generated measured; the matter medium may be aluminium or lead. But calorimetry often poses great practical difficulties. The indirect method is to measure the speed of the electrons and to apply the kinetic energy formula to compute energy. But the speed of the electron may be measured directly using the time-of-flight method or by other indirect techniques. During the 1920s, the technology to directly measure the speed of an electron was not available. All measurement of electron speed had to be done indirectly. The method used to measure the speed of electrons then was based on the J.J. Thomson 1897 experiment to measure the charge-to-mass ratio of the electron; it was a method using the Lorentz electric and magnetic force for charged particles.

After the Thomson experiment, various experiments were carried out to establish the relativistic nature of the mass of the electron. One such experiment was the Bucherer experiment of 1908 [2]. Following these, the relativistic mechanics was widely accepted. In experiments with beta decay, all energies are relativistic energy as the speed of the ejected electrons are comparable to that of light speed. As described in another paper of the author [3], the velocity of the electrons leaving the Bucherer experiment capacitor is:

$$v_y = \sigma/\epsilon_0 B_z \tag{1}$$

σ is the charge densities of the capacitor which could be changed through changing the capacitor voltage; B_z is the uniform magnetic field that could also be changed. By varying the balance of the electric and the magnetic fields, the Bucherer experiment would be able to select beta particles of a specific energy that emerge from the apparatus. The energy of the particle could than be computed from the kinetic energy formula using the velocity from equation (1). The energies of the beta electrons were computed using the relativistic energy formula where kinetic energy is the now familiar $(\gamma - 1)m_0c^2$, not the classical $\frac{1}{2}mv^2$. This is so as a classical beta electron of 1.05 MeV would have had a speed of 2.0c! Energy of particles going at relativistic speed (speed comparable to that of light) has always been measured indirectly, never directly. Even today in particle physics, the energies of subatomic particles are all estimated theoretical values, not direct values measured experimentally.

We need not go into the details of the Ellis-Wooster calorimetry apparatus. We go straight into the result of the experiment and the conclusion. The result was an average heating effect of 350,000 eV per beta particle with an estimated accuracy of 10%. We note here that the experiment was repeated by Meitner and Orthmann later in 1930 with an improved apparatus and they obtained an average energy of 337,000 $\pm$ 20,000 eV; this result was in excellent agreement with that measured by Ellis and Wooster. The conclusion was that the average captured heat of 350,000 eV might be taken to agree with the average disintegration energy of 390,000 eV. This meant that the nature of beta decay might be different from that for alpha decay; there was no fixed quantised disintegration energy where secondary effects caused the emitted particles to lose energy in its passage leaving the atom or the radioactive source; this would have had explained the continuous energy spectrum of beta decay. The result seemed to indicate that every beta decay atom disintegrated with different energy that might range from a low to a distinct cutoff maximum. But such a conclusion would be at odds with the law of conservation of energy and this was a critical situation.

3. Wolfgang Pauli And His Neutrino Hypothesis

Wolfgang Pauli wanted to resolve the continuous spectrum controversy of beta decay and to leave the law of conservation of energy unchanged. He preferred the idea that beta decay disintegrates with a quantized fixed amount of energy. In order to resolve the contradiction this had with the conclusion of the Ellis-Wooster experiment, he proposed that there was another small uncharged particle - hitherto undetected - that was emitted along with the beta particle. He named the new particle "neutron" (what Enrico Fermi renamed the "neutrino") and assumed it was more penetrating than gamma rays, thus escaping capture by the Ellis-Wooster calorimeter. The energy of the neutrino and the energy of the beta particle would always add up to the fixed quantized energy of beta decay. This neutrino would explained the *missing energy* of the Ellis-Wooster experiment. He sent a letter to a meeting of physicists as he was not able to attend in person.

Open letter to the radioactive group at the regional meeting in Tübingen, 1930:

> *Dear Radioactive Ladies and Gentlemen,*
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> *...Namely the possibility that electrically neutral particles, which I would like to call neutrons, might exist inside nuclei; these would have spin 1/2, would obey the exclusion principle, and would in addition differ from photons through the fact that they would not travel at the speed of light. The mass of the neutron ought to be about the same order of magnitude as the electron mass, and in any case could not be greater than 0.01 proton*

> *masses. The continuous beta spectrum would then become understandable by assuming that in beta decay a neutron is always emitted along with the electron, in such a way that the sum of the energies of the neutron and electron is a constant. ...*

Although Pauli's proposal was not fully accepted in the beginning, Enrico Fermi in 1933 expanded on it and developed a theory of beta decay based on the neutrino. The rest is history. The 1995 Nobel Prize was even awarded to Cowan and Reines for their detection of the neutrino in their 1956 experiment.

The very basis upon which Pauli proposed the neutrino was the very conclusion of the Ellis-Wooster experiment of 1927; that if the beta decay energy was a fixed amount of 1.05 MeV, the captured heat was missing some energy - thus the notion of *missing energy*. If a reinterpretation of the Ellis-Wooster experiment were to conclude that there never was any missing energy, the very basis for Pauli's neutrino proposal would not have had existed. The literature of physics would then not have the neutrino.

> *The very basis for Pauli's neutrino proposal would have been non-existent if a reinterpretation of the Ellis-Wooster experiment of 1927 were to conclude there was no missing energy; the literature of physics would not have had the neutrino.*

The following sections would be devoted to examine if there was any missing energy.

4. Calorimetry, Special Relativity and Newtonian Mechanics

There is a need here to discuss in some details the mechanics of special relativity and Newtonian mechanics and how they should relate to calorimetry, the method used in the Ellis-Wooster experiment. A more detailed analysis can be found in another paper of the author [4].

Let's begin with the second postulate of Einstein's special relativity:

> *The speed of light in free space is a universal constant and is invariant in all observer frame of reference.*

Speed in Newtonian mechanics is a simple concept defined as: distance/time, the distance traversed during a time duration. Newtonian mechanics is developed within the physical dimensions of absolute space (length) and universal time. These two dimensions are as the axioms of mathematics - they belong to the fundamental abstract framework within which the mathematics of length and time measurements are founded upon. A dimension's metric is an invariant property that cannot change within a physical theory nor could the nature of the dimensions be treated and examined as subject-proper within a physical theory. This is in stark contrast with special relativity where the space and time metrics could change and the nature of space and time could be subject-proper treated and examined within the theory.

By definition, speed in Newtonian mechanics is observer dependent because of how it is defined with distance and time; it transforms under the Galilean transformation. The concept of speed does not distinguish if it is a measure of speed of a material body or that of light radiation. Einstein used the same term "*speed*" in his second postulate, but introduced a speed - that of light - that was observer invariant. This is in direct contradiction with the concept of speed as defined within Newtonian mechanics. With a *stroke-of-the-pen*, Einstein created a new mechanics - another mechanics - that is independent from Newtonian mechanics; the two are absolutely unrelated and independent of each other. Special relativity created a totally new "*physical reality*" different from "*Newtonian reality*". The world of physics is now faced with a physical dichotomy - the real world may only have one physical reality.

We come back to the Ellis-Wooster experiment. As we have noted earlier, the energy in figure (1) is relativistic energy. Ellis-Wooster based their conclusion by comparing the heat captured of 350,000 eV with the average relativistic energy of 390,000 eV. If heat energy of calorimetry is consistent with relativistic energy, then there is no issue at all with the conclusion of Ellis-Wooster. But if heat energy is only consistent with classical kinetic energy, then the conclusion of the Ellis-Wooster experiment would not hold.

In figure (1), the classical equivalent energy values are given in brackets. If we were to re-calculate the average classical energy of the spectrum, we need to have the original data and plot the curves anew in order to compute the value. Because the conversion is not linear, the figure of 170,000 eV does not represent the true classical average; we know the true figure is less than 170,000 eV. For the purpose here, we may just assume a rouge figure of 120,000 eV which is about half of the classical maximum value of 230,000 eV. So now, with classical kinetic energy, the captured heat of 350,000 eV is way beyond 120,000 eV. Not only would the conclusion of missing energy be untenable, the surplus of captured heat over the average spectrum energy would support the idea that there was indeed "*secondary effects*" that reduced the energy of the emitted electrons; this explains the continuous energy distribution spectrum of beta decay. The argument proposed in this paper is that the lost of energy is due to the scattering by the outer electrons as the beta particle leaves the decaying atom. In the case of alpha decay, the outer electrons would not cause much opposition to the alpha particle leaving the atoms as its mass is 1836 x 4 times greater than that of the electron; furthermore, it is positively charged. In contrast, the beta particles are electrons having the same small mass of the outer electrons; the outer electrons would be able to have a strong electrical ability to oppose the ejected beta electron's passage leaving the decaying atoms. With such a conclusion, the idea of any missing energy would not be tenable.

> *The idea of "missing energy" would not be tenable if heat energy is consistent with classical kinetic energy; the basis for Pauli's neutrino hypothesis would then be non-existent.*

There are further issues if we assume heat energy is consistent with classical kinetic energy:

(1) The captured heat of 350,000 eV is greater then the maximum spectrum energy of 230,000 eV! There must be an error with one of the values as we cannot capture more than the disintegration energy of decay. As we have noted earlier, the Ellis-Wooster heat figure of 350,000 eV was confirmed independently to be reliable. So where is the mistake in the figure of 230,000 eV? There is an answer.

The conversion of relativistic to classical kinetic energy is done using the relativistic kinetic energy formula of: $KE = (1/\sqrt{1-v^2/c^2}-1)m_0c^2$. With the velocity v found, the classical kinetic energy would be: $\frac{1}{2}mv^2$. But why is that the equivalent average classical energy does not work out to be 350,000 eV? The reason is that the velocity v may be wrong. The velocity v found from any relativistic formula is consistent only with special relativity and cannot be used in the classical kinetic energy formula $\frac{1}{2}mv^2$. A way to resolve this inconsistency is to measure directly the velocity with which beta particles are ejected using the time-of-flight method and to use it to compute kinetic energy.

(2) A classical electron with energy 350,000 eV would have a speed of 1.17c - greater then the light speed! There is the consensus today that speed of any body cannot exceed that of light. So can heat energy be consistent with classical energy? Yes. The notion that the light speed is the speed limit in nature belongs only to the "*physical reality*" of special relativity, never in the "*physical reality*" of Newtonian mechanics; the two incompatible "*worlds-of-nature*" do not and cannot mix. There is nothing in Newtonian mechanics that restricts the speed of a body to that of the light speed.

In the particle physics of today, kinetic energy is never an experimentally measured quantity. Neither is the speed of particles measured directly through the time-of-flight method nor the energy measured through calorimetry; all energy values are theoretical estimates.

Within particle accelerators - such as the LHC of CERN - charge particles are accelerated through electrical boost relying on the Lorentz electrical force law: $\mathbf{F} = q\mathbf{E}$; every boost will cause the charge q to pass a potential difference of a certain voltage of V giving an extra boost energy of qV. The energy the particle should have reached is computed by summing all the boosts a charged particle receives while being accelerated within the accelerator. This is how the proton's energy of 7 TeV reached within the LHC of CERN was estimated.

In the paper [3] of the author, it is shown that the Lorentz force law is incorrect as a law in electromagnetism; it is only approximately valid for very small speed of charged particles. For speeds significant as compared to the light speed, the force law is incorrect. In fact, the electric, as well as the magnetic force, approaches zero when the particle speed approaches that of the light speed c. So the theoretical assumption that energy could be estimated by adding all electrical boost is wrong; the boost amount based on $q\mathbf{E}$ is dependent on the speed of the charged particles. The method used to estimate energy in today's particle physics is incorrect. If the physical reality of nature is Newtonian, then the proton's energy of 7 TeV would be below $\frac{1}{2}m_pc^2$, or at most 470 MeV - off by a factor of 15,000! Physical reality is either consistent with special relativity or with Newtonian mechanics; the two mechanics are two mutually independent and unrelated *worlds-of-nature*. If we know which is the correct mechanics of nature, then we would know if calorimetric heat is relativistic or Newtonian.

There was an attempt by William Bertozzi of the MIT to decide on whether heat was consistent with special relativity or with classical kinetic energy. He conducted an experiment [5] in 1964 where he accelerated electrons generated with a Van de Graaff generator in a linear accelerator to energy of 0.5 MeV to 15 MeV. Some of the runs of the experiment had the electrons being captured in aluminium where he measured the heat generated directly with calorimetry; the speed of the electrons too was measured directly with the time-of-flight method. He found that the result shows calorimetric heat to be consistent with special relativity (with a 10% uncertainty) and clearly inconsistent with classical energy. If we accept the finding of the Bertozzi experiment, then the issue of whether physical reality is consistent with special relativity or with Newtonian mechanics would have been settled. Indeed! The world of physics took the one single 1964 Bertozzi experiment to confirm special relativity and to completely dismiss Newtonian mechanics.

The physics world accepted a single uncorroborated 1964 experiment of one William Bertozzi to dismiss 300 years of Newtonian mechanics.

There is scant rationality how one single uncorroborated experiment could carry such clout and authority to dismiss 300 years of classical physics that have never ever shown any incontrovertible failure. Until today, no one has attempted to replicate the Bertozzi experiment nor was there any attempt to carry out other experiments to settle if special relativity or Newtonian mechanics is correct.

The Ellis-Wooster experiment happens to provide a clue to a simple way to resolve the issue; the clue is in the captured heat of 350,000 eV. A classical electron with an energy of 350,000 eV would have a speed of 1.17c. An experiment could be devised to measure directly the speed with which electrons are ejected from the beta decay of Bismuth-210 (Radium E) using the time-of-flight method. If heat is Newtonian, then the maximum speed would be found to exceed that of the speed of light; otherwise, it would be a confirmation that calorimetric heat - and thus physical reality - is relativistic. But until today, no attempt has ever been done to directly measure the speed of particles ejected through beta decay; all measurements of such speed are done through the method relying on magnetic deflection as represented by the equation (1) given earlier.

> *The question of whether physical reality is consistent with special relativity or with Newtonian mechanics could be settled unequivocally by directly measuring the speed of beta particles ejected from beta decay with the time-of-flight method. If Newtonian mechanics is correct, then, for some decays with high enough disintegration energy, the maximum speed of particles would be greater than the light speed; otherwise, it would be evidence that physical reality is consistent with special relativity. Despite its paramount importance, this experiment has yet to be carried out.*

As we have shown earlier, the neutrino exists only in the reality of special relativity, but not in the classical Newtonian world. Whether the neutrino exist or not exist may only be decided through the result of the experiment just described. The current neutrino physics is all based on special relativity which has not been experimentally verified incontrovertibly.

5. Conclusion

The basis upon which Wolfgang Pauli proposed his 1930 neutrino hypothesis was the conclusion of the 1927 Ellis-Wooster experiment which supposedly supported the idea of "*missing energy*" in beta decay. The question of whether there was any missing energy depends on whether physical reality is consistent with special relativity or with Newtonian mechanics. The neutrino and the current neutrino physics would remain if special relativity is the correct mechanics representing the physical world. On the other hand, if physical reality is consistent with Newtonian mechanics, then special relativity would have to be rejected; all of neutrino physics too would have to be dismissed. The one experiment that could decide on the issue is to determine the maximum speed with which beta particles are ejected in beta decay using the direct time-of-flight method. If Newtonian mechanics is the correct mechanics representing physical reality, then there would be beta particles found to go beyond the light speed; otherwise, it would be experimental evidence supporting special relativity. The result of this experiment would settle unequivocally the question concerning the nature of physical reality. But to date, this experiment has not been carried out.

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Email address: chanrasjid@gmail.com
URL: http://www.emc2fails.com

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