Energy Nonconservation Experimental Facts Ignored by Millikan in 1916

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***Abstract*—Basing on analyses for the data of photoeffect, observed by Millikan in 1916, this paper finds that the energy in the photoeffect are not conservative obviously nearby the cutoff frequency, and that the scales of the nonconservative energy fit quantitatively the theoretical prediction in 2013. The causes that the energy nonconservation phenomenon was ignored by Millikan in 1916 are: (1). The wrong measurement made by Millikan's assistant for the relative intensity of the spectrum of his mercury lamp; (2). Absolute belief for the energy con-servation law in any cases.**

***Key Words*— Photoeffect， Energy nonconservation, Einsten equation, Cutoff frequenct, Photocurrent.**

I. INTRODUCTION

To explain the radiation formula of black body, Planck hypothesized in 1900 that when a black body absorbs or emits electromagnetic waves, it can only be in a quantum hf [1]. To explain the data on the photoeffect, Einstein hypothesized in 1905 that the electromagnetic wave was composed of localized bundles, i. e., photons, and according to the energy conservation law wrote an equation:

$$E_{kin} = hf - W; \qquad (1)$$

Where E_{kin} is the maximum kinetic energy of electrons, W is the sample surface's work function. Millikan wrote a paper in 38 pages in 1916 to verify Eq. (1) [1]. Ref. [1] is the determinant verification for Eq. (1). Eq. (1) is now called as Einstein photoeffect equation, or, simply, Einstein equation. All the three scientists won the corresponding Nobel Prizes for theirs works, respectively. Here, we would like to remind readers to remember that the holding conditions of Eq. (1) are two: (i). The hypothesis of photon; (ii). Energy conservation.

This paper notes in Millikan's 1916 paper that in the experimental data of the three samples the fitting curves nearby the cutoff frequency were dotted other than solid [1]. This paper studies the reason to use dotted lines other than solid lines, and finds that Millikan's photoeffect experimental data near-by the cutoff frequencies clearly and directly show energy nonconservation. It is a big pity that Millikan ignored this important discovery in 1916.

Section 2 introduces the data for Millikan's three samples nearby the cutoff frequency, and Millkan's viewpoint. Section 3 argues qualitatively that Millikan's data nearby the cutoff frequencies directly show energy nonconservation nearby the cutoff frequencies. Section 4 makes quantitative analyses for scales of the energy nonconservation, and comparisons with theoretical prediction in 2013 in Ref. [2,3]. Section 5 makes conclusion and discussions.

II. MILLIKAN'S DATA NEARBY THE CUTOff FREQUENCIES AND VIEWPOINTS

In Millikan's 1916 paper there were three samples: Sample 1 is sodium surface; Sample 2 is new lithium surface; Sample 3 is the same lithium surface several months later. The three fitting curves of Millikan's data are shown in Fig. 1 [1]. (E_{kin} in Fig. 1 is obtained by the measurements of stopping voltage.) It is noteworthy that all the three fitting curves nearby the cutoff frequencies are dotted lines other than direct lines. Although all the same kind of curves after 1916 to 2014 is solid, this paper still likes to study the causes to use the dotted lines other than solid. We call the cutoff frequency, determined by these direct lines, $f_{Einstein}$. Millikan obtained the cutoff frequencies of the three samples as $f_{Einstein}$ = 43.9; 57; 59.7($\times 10^{13}$) Hz, respectively. From the three direct lines and Eq. (1) Millikan obtained h = 6.56; 6.569; 6.584×10 ^{27} erg.second for the samples 1, 2, and 3, respectively.

It is noteworthy to note that every fitting direct line in Fig. 1 consists of solid and dotted parts. In the following this paper explains that why Millikan did not express the whole line as solid.

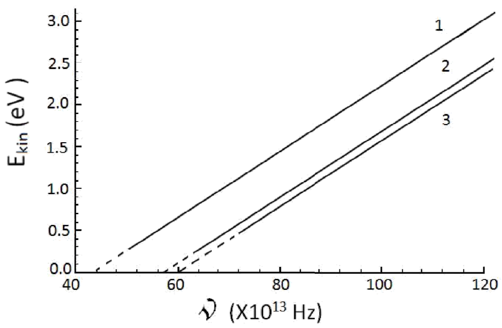

Figure 1: Diagrams of E_{kin} (eV) versus f($\times 10^{13}$ Hz). E_{kin} represents the maximum kinetic energy of the electron ejected from the sample's surface. f is the frequency of

photon. The three curves 1, 2, and 3 belong to the samples 1, 2, and 3, respectively [1].

Sample 1:

In the 11th row of page 366 of Ref. [1], Millikan said: "sample 1 was sensitive up to the cutoff frequency $f_{Einstein}$ = 43.9 × 10^{13} Hz." However, Millikan did not use the stopping voltage measurement to give the scale of the value of E_{kin} at the cutoff frequency. Millikan decided to directly determine the exact cutoff frequency $f_{Millikan}$ by saturating photocurrent measurement. Millikan drew a diagram of saturating photocurrent in unit light intensity versus frequency of photon, which is shown in Fig. 2. The method to fitting the data is the so called smooth curve method. From fitting for the threepoints, Millikan obtained the cutoff frequency $f_{Millikan}$ = 44.12 × 10^{13} Hz, which is really approximately equal to $f_{Einstein}$ = 43. 9 × 10^{13}.

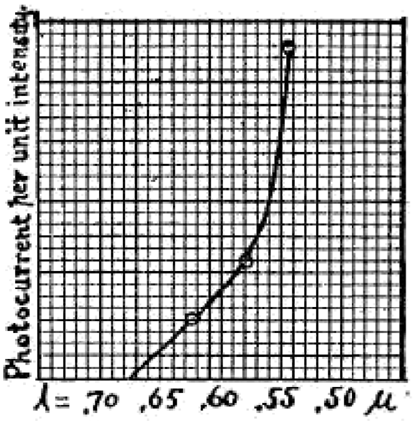

Figure 2: Diagram of observed saturating photocurrent per unit light intensity in arbitrary unit versus (*m*) for the sample 1. This diagram comes from the figure 10 of Ref. [1].

Sample 2:

Millikan's data are given in Fig. 3. To obtain the cutoff frequency $f_{Millikan}$, Millikan considered only three points, made fitting, and gave $f_{Millikan}$ =57.25 ×10^{13} Hz, which is really approximately equal to $f_{Einstein}$ = 57.0 ×10^{13}.

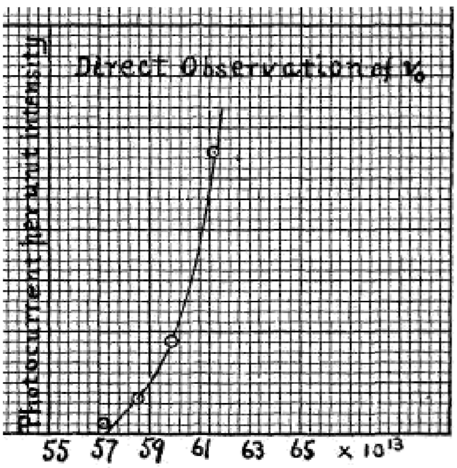

Figure 3: Diagram of observed saturating photocurrent versus *f*(×10^{13} Hz) for the sample 2. This diagram comes from the figure 8 of Ref. [1].

Sample 3:

Millikan's data are given in Fig. 4. To obtain $f_{Millikan}$, Millikan, made smooth fitting, and gave $f_{Millikan}$ = 59 × 10^{13} Hz, which is clearly less than $f_{Einstein}$ = 59.7 × 10^{13}.The Millikan's viewpoint for his data of the three samples nearby the cutoff frequencies is as follows. Millikan said about the sample 3 in page 381: "I should be unwilling to claim that the direct observations through photocurrent fix
the cutoff frequency $f_{Einstein}$ with a precision greater than 0.7×10^{13} ≈ 100Å."

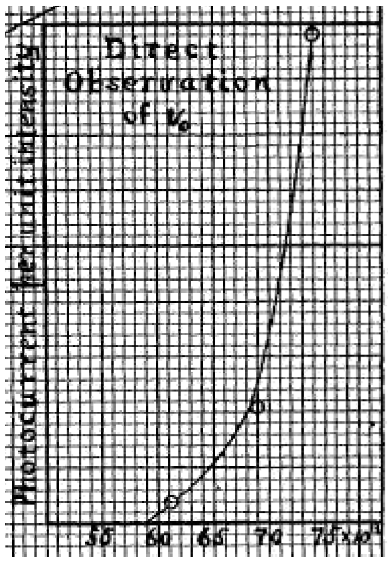

Figure 4: Diagram of observed saturating photocurrent versus *f*(×10^{13} Hz) for the sample 3. This diagram comes from the figure 9 of Ref. [1].

Then, considering the approximate fixing between $f_{Einstein}$ and $f_{Millikan}$ of the samples 1 and 2, Millikan said: "Nevertheless these three observations seem to leave no room whatever for the doubt that the agreement demanded by Einstein equation between the photocurrent and stopping voltage methods of determining the cutoff frequency actually exists."

Here, this paper would like to remind readers to note that "unwilling" and "seem" are not scientific language. We think that due to that Millikan cannot use scientific language to make conclusion, Millikan had no alternative but to use the three dotted lines nearby the cutoff frequencies other than the three whole solid lines in Fig. 1.

III. OUR QUALITATIVE ANALYSES

Sample 1:

The experimental fact that the electrons with non-zero kinetic energy are ejected from the surface of sample 1 after absorbtion of a photon with energy hf = W at the cutoff frequency means that the energy in photoeffect is not conservative at the cutoff frequency.

It is a big pity that Millikan did not make study for this phenomenon in detail, and did not give the observed value of E_{kin} at the cutoff frequency. On the contrary, Millikan decided to directly determine the exact cutoff frequency $f_{Millikan}$ by saturating photocurrent other than stopping voltage.

In 1916 Millikan cannot find the intensity of spectrum of his mercury lamp nearby the cutoff frequency. His assistant made measurement of the spectrum of his mercury lamp nearby the cutoff frequency. Here, it is bigger pity that his assistant made two completely wrong measurements. (i). His assistant thought: "For the yellow lines 5,790 and 5,770 Å produced together a saturating photocurrent which was 56/113 of that produced by line 5,461 Å." However, according to any present available references such as Ref. [4], the spectrum has only one peak, which is at 5,790 Å. Therefore, we think that it is only that the yellow line 5,790 Å produced saturating photocurrent, which was 56/113 of that produced by line 5,461 Å; (ii). His assistant gave, "the ratio of the light intensity at 5,790 and 6,235 Å is R_{light} = 10 : 1. However, Ref. [4] gives $R_{light} \approx$ 10.4 : 0.8. From his assistant' s wrong measurements,

Millikan said: "the light intensity ratio R_{light} at 5,461, 5,780 and 6,235 Å is71, 100, 10."

According to Ref. [4], this paper thinks that R_{light} should be 71 : 71 ×10.4/17.5 : 71 × 10.4/17.5 × 10.4/0.8 = 71 : 42.194 : 3.246.

Next, we discuss the ratio of saturating currents per unit light intensity $R_{current}$. For this purpose, at first we introduce Millikan's data. Millikan said: "Also the red line 6,235Å produced a marked saturating photocurrent of value 1/20 of that of the yellow." Therefore, Millikan said: "From these data the saturating photocurrents per unit light intensity for these three light lines are found to be ration $R_{current}$ = 140 : 50 : 25." Here, the "50" comes from 50 $\approx$ 140 × 56/113 × 71/100 = 49:26, and the "25" comes from25 $\approx$ 140 × 56/113 × 71/100/20 × 10/1 = 24.63.

However, according to Ref. [4], this paper thinks $R_{curremnt}$ = 140 : 140 × 56/113 × 71/42.194 : 140 × 56/113 × 71/42.194 × 1/20 × 10.4/0.8 = 140 : 116.747 : 75.885." Using the correct data, given by this paper in Fig. 5, and the smooth fitting method (Polynomial precise fitting method) in Ref. [5],we obtain the curve in Fig. 5. Our fitting curve gives Our = 6950 Å(f_{Our} =43.14× 10^{13}Hz). Fig. 1 clearly gives that at $f_{Einstein}$ = 43.9 × 10^{13} Hz(=6829 Å) $E_{kin} \neq 0$, which means the energy nonconservation at $f_{Einstein}$.

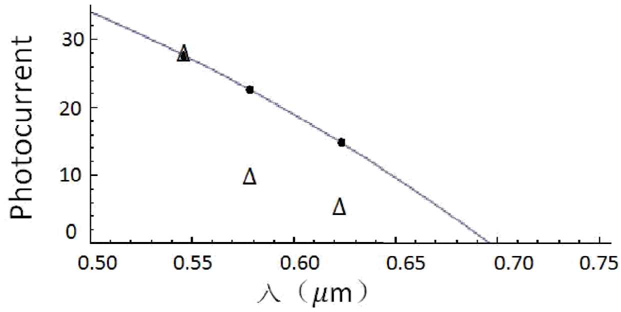

Figure 5: Diagram of observed saturating photocurrent versus (m) for the sample 1. The solid circles are our correct treatment for Millikan's original data. The three triangles comes from Fig. 2, and are the original data given by Millikan [1].

We point out the following two points:

(1). For this sample, $f_{Einstein}$ = 57 × 10^{13} Hz and $f_{Millikan}$ = 57.18 × 10^{13}Hz. We remind readers to note that from Fig. 3 we see that at f = 57.08 × 10^{13} Hz the observed photocurrent is not small, which means that at f = $f_{Einstein}$ = 57 × 10^{13} Hz the photocurrent might be not zero, i. e., the energy at $f_{Einstein}$ = 57 × 10^{13} Hz might do not conservative. (2). We do not think that there is any reason to neglect the fourth point in Fig. 3. This paper considered all the four points in Fig. 3 other than the three points as that in Millikan's paper. After our smooth fitting [5], we obtain Fig. 6, and from Fig. 6 f_{Our} = 56.3×10^{13} Hz, which means the energy nonconservation at $f_{Einstein}$.

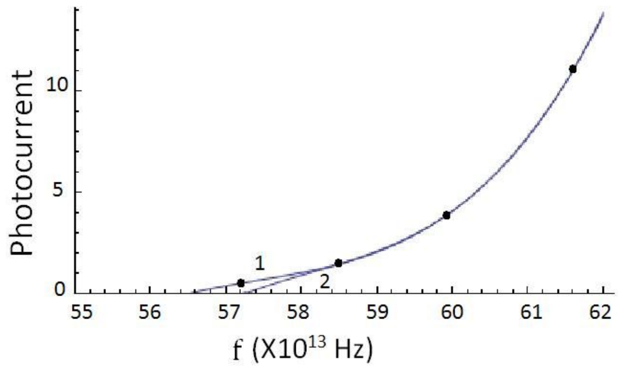

Figure 6: Diagram of observed saturating photocurrent versus f(×10^{13} Hz) for the sample 2. The circles are from Fig. 3. The curves 1 and 2 come from our and Millikan fitting, respectively.

For the sample 3:

In fitting curve of Fig. 4, Millikan considered only two points to pass through his fitting curve, and gave the curve 1 in Fig. 7. Our fitting forthe data in Fig. 4 is to set all the three points to pass through our fitting curve, and gives the curve 2 in Fig. 7. Fig. 7 shows $f_{Millikan}$ = 59 × 10^{13}<$f)_{Einstein}$ Hz and f_{Our}= 58.5 × 10^{13}< $f_{Einstein}$Hz. Both $f_{Millikan}$= 59

$\times 10^{13} < f)_{Einstein}$ Hz and $f_{Our} = 58.5 \times 10^{13} < f_{Einstein}$ Hz mean the energy nonconservation at $f_{Einstein}$.

The conclusion of our qualitative analyses for the data of all the three Millikan's samples are the energy nonconservation nearby the cutoff frequencies.

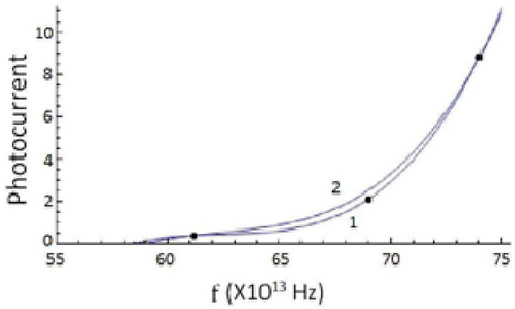

Figure 7: Diagram of observed saturating photocurrent versus $f(\times 10^{13}$ Hz) for the sample 3. The circles are from Fig. 3. The curves 1 and 2 come from our and Millikan fitting, respectively.

IV. Our Quantitative Analyses

We note that Ref. [2] gave the scale of the energy nonconservation at the cutoff frequency is 0.018 eV. Let us make comparisons of scales of energy nonconservation at the cutoff frequencies between Millikan's data and the theoretical value in Ref. [2]. These comparisons are shown in Figs. 8, 9, and 10. From Figs. 8, 9, and 10 we see that the maximum values of energy nonconservation at the corresponding cutoff frequencies are only a little larger than the theoretical value of energy nonconservation 0.018 eV.

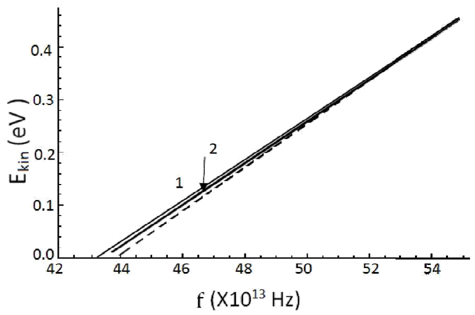

Figure 8: Diagram of E_{kin} (eV) versus $f(\times 10^{13}$ Hz) for the sample 1. The dotted line is the same as the left dotted line in Fig.1. The curve 1 is the direct line between (54.90 $\times$ 10^{13} Hz*;* 0.4504 eV) and (43.14 $\times$ 10^{13} Hz*;* 0 eV). The curve 2 comes from Ref. [2]. If at $f_{Einstein} = 43.9 \times 10^{13}$ Hz the energy is conservative, then according to Einstein equation $E_{kin} = 0$. From the curve 1, $E_{kin;max} = 0.029$ eV at $f_{Einstein} = 43.9 \times 10^{13}$ Hz, which should be the maximum value of energy nonconservation at $f_{Einstein}$.

V. Conclusions and Discussions

Sections 3 and 4 tell us that in Millikan's 1916 paper there are the followingeight experimental facts:

For the sample 1:

(1). $E_{kin,Einstein} > 0$ at $f_{Einstein}$.

(2). Photocurrent > 0 at $f_{Einstein}$, which means $E_{kin,Einstein} > 0$ at $f_{Einstein}$.

(3). The scale of $E_{kin,Einstein}$ at $f_{Einstein}$ is consistent with the theoretical prediction in 2013.

For the sample 2:

(4). $E_{kin,Einstein} > 0$ nearby $f_{Einstein}$.

(5). Photocurrent > 0 at $f_{Einstein}$, which means $E_{kin,Einstein} > 0$ at $f_{Einstein}$.

(6).The scale of $E_{kin,Einstein}$ at $f_{Einstein}$ is consistent with the theoretical prediction in 2013.

For the sample 3:

(7). *Photocurrent* > 0 at $f_{Einstein}$, which means $E_{kin;Einstein} >$ 0 at $f_{Einstein}$.

(8). The scale of $E_{kin;Einstein}$ at $f_{Einstein}$ is consistent with the theoretical prediction in 2013.

Therefore, it is not difficult to understand that from both qualitative and quantitative analyses in sections 3 and 4 for the Millikan's data on the photoeffect in all the three samples, this paper can make two doubtless conclusions: (1) The energy at the cutoff frequencies in the photoeffect is not conservative; (2) . The energy conservative theory on the photoeffect in References [2] and [3] can fit the Millikan's data quite well. Recently, more and more authors have noted the possibility of energy nonconservation in many physical processes. Lepe et al found the sign of the amount of energy nonconservation in cosmology [6] and [7]. Based on many recent references, Cahill pointed out that in anisotropic Brownian motion and the detected in correlations between ocean temperature fluctuations and so lar flare counts there might be energy nonconservation, which violate the first thermodynamics [8]. Cahill further pointed out that this energy nonconservation can explain why the Earth temperature record so closely tracks solar flare counts, and fundamentally then it is implied that the Earth climate is controlled by a nonconservation of energy process. In comparison of our paper with all the studies on the energy nonvconservation until now we feel that it is only that our paper can make the investigation from both the exact theory and precise measurement simultaneously.

VI. References

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