Dimming the Light Does Not Change the Ratio of the Wave's Charging Time to the Wait for the First Photoelectron

— the time for a wave to gather one work function through the cross-section of one atom and the mean wait for the first photoelectron from a receiving surface are both inversely proportional to intensity, and their ratio is set by the ratio of areas and the quantum efficiency — the separator is whether the energy is received over one atom's cross-section or over the whole receiving surface — [Paper 1011]

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— *From thinking to syncing.* —

Abstract

Light on a metal knocks out electrons whose maximum energy is set by the light's frequency and does not grow with intensity (Einstein 1905).This paper checks the photoelectric effect with the stopping-voltage line and the number of photoelectrons, and in weak light compares the time for a wave to gather energy with the wait for the first photoelectron.No new theorem or law is claimed, and the cross-section, receiving surface, quantum efficiency and work functions are example values. First, the slope of the stopping-voltage line is h/e whatever the work function ——fitting lines to 8 noisy points each for surfaces with work functions 2.0 eV and 4.5 eV gave slopes 4.139190×10^{-15} and 4.140939×10^{-15} V·s (h/e is $4.135667697\times10^{-15}$), with ratio 0.999578 and intercepts -2.002349 V and -4.513303 V (Section 2). **Second, intensity raises the number of photoelectrons, not the upper limit of one electron's energy——raising the intensity 1000 times raised the number proportionally (log slope 1.000113), and the maximum kinetic energy never exceeded the photon energy 3.099605 eV minus the work function 2.3 eV, 0.799605 eV** (Section 3). **Third, and this is the core. Dimming the light does not change the ratio of the two times ——the time for a wave to gather one work function through the cross-section of one atom (10^{-20} m²) and the mean wait for the first photoelectron from a 1 cm² surface (quantum efficiency 0.1) are both inversely proportional to intensity, and over 12 decades of intensity their ratio stayed at 7.420300×10^{14}. The ratio equals the product of the area ratio, the quantum efficiency, and the work function over the photon energy** (Section 4). **Fourth, at 10^{-6} W/m² the wave gathers for 1.167708 years, while a photoelectron comes out after 4.966115×10^{-8} s on average——the wave's time is 3.685006×10^{7} s (1.167708 years) and the mean wait 4.966115×10^{-8} s; in 1000000 random trials the wave's time was never waited for, and the slowest wait was 2.052711×10^{-14} of it** (Section 5). **Fifth, the wait follows an exponential distribution——the mean of the random waits was 4.968379×10^{-8} s (1/R is 4.966115×10^{-8}) and the median 3.446618×10^{-8} s (ln2/R is 3.442248×10^{-8})** (Section 5). **Sixth, the separator is whether the energy is received over one atom's cross-section or over the whole receiving surface——the wave's clock runs at the rate one atom's cross-section collects energy, and the photon's clock at the rate photons reach the whole surface, so intensity acts equally on both and only the area ratio remains** (Section 6). **Keywords**: photoelectric effect, work function, stopping voltage, photon, Poisson process, quantum efficiency.

Scope of this paper (scope note): **No new theorem or law is claimed——Einstein's photoelectric equation (1905), that the slope of the stopping-voltage line is h/e (Millikan 1916), that photon arrivals can be written as a Poisson process, and the estimate that a classical wave takes time to gather energy are all known.Counting uses example values——the atomic cross-section 10^{-20} m², receiving surface 1 cm², quantum efficiency 0.1, wavelength 400 nm, and work functions 2.3, 2.0 and 4.5 eV are examples, not values of real metals.The energy distribution of photoelectrons is not treated——kinetic energies were placed uniformly between 0 and the upper limit; this is not the real distribution.Experimental delay values are not treated——values from experiments that measured the delay before photoelectrons appear are not given.Relation to earlier papers**: **the scope note of Paper 448 said that it does not discuss speed, such as how many years a dye takes to fade, looking only at whether a bond breaks; this paper is placed beside it and counts the time until light releases an electron (in the item "reaction mechanisms are not discussed" of the same scope note, Paper 668 sat and counted a hundred-million-fold difference in luminescence times).Paper 448 showed through the energy of one photon that no amount of red light breaks a bond that blue light breaks——here it is counted that the same per-photon pattern separates the number of photoelectrons from their energy limit and also appears in the wait time; no common root is claimed.Paper 270 showed that the difference between flux quanta h/e and h/2e is the number of carriers——here the same h/e appears as the slope of the stopping-voltage line; no common root is claimed.Paper 1005 showed that the ratio of stimulated to spontaneous emission is the occupation number——here the fraction of arriving photons that release electrons is set as the quantum efficiency, and the fluctuation of arrivals is counted.**What is added is **confirming from noisy measurements that the stopping-voltage lines of two surfaces share the slope h/e**, **counting that the number of photoelectrons is proportional to intensity while the energy limit does not change**, **showing that the ratio of the wave's gathering time to the wait for the first photoelectron is independent of intensity and set by the area ratio and quantum efficiency**, and **generating wait times at random and counting that the wave's time is never waited for**.

1. Notation and the Question

Setting: **a photon of frequency ν carries $h\nu$, and with work function φ the photoelectron energy limit and stopping voltage satisfy $eV_s = h\nu - \varphi$.For light of intensity I, the time for a classical wave to gather one work function through an atomic cross-section σ, and the rate R at which a surface A (quantum efficiency η) releases photoelectrons, are set as follows.**

$$t_{\text{wave}} = \frac{\varphi}{I\sigma}, \qquad R = \frac{IA\eta}{h\nu}, \qquad \frac{t_{\text{wave}}}{1/R} = \frac{A}{\sigma}\,\eta\,\frac{\varphi}{h\nu}$$

h, e and c are the SI defined values, and $h/e = 4.135667697 \times 10^{-15}$ V·s.

Question: **what does stronger light increase, and what does it not? Does dimming the light widen the gap between the wave's clock and the photon's clock?**

2. The Stopping-Voltage Line

Computation 2.1: for surfaces with work functions 2.0 eV and 4.5 eV, stopping voltages with spread 0.01 V were generated at 8 points from 1.1 to 2.5 times the threshold frequency, and lines were fitted.

work function	threshold frequency (Hz)	threshold wavelength (nm)	slope (V·s)	intercept (V)
2.0 eV	4.835978×10^{14}	619.921	4.139190×10^{-15}	−2.002349
4.5 eV	1.088095×10^{15}	275.520	4.140939×10^{-15}	−4.513303

> **Observation 2.2**
>
> the slope of the stopping-voltage line is h/e whatever the work function.Both slopes were within 1 percent of h/e, with ratio **0.999578**, and the intercepts were minus the work function over e——changing the surface only shifts the line in parallel; the slope does not change. The first run placed frequencies in Hz directly as a least-squares column, which scaled badly and gave intercept 0 and half the slope; refitting in units of 10^{15} Hz fixed it.

3. Changing the Intensity

Computation 3.1: at wavelength 400 nm (photon 3.099605 eV), work function 2.3 eV, surface 1 cm² and quantum efficiency 0.1, photoelectrons in 1 second were counted with Poisson random numbers.

intensity (W/m²)	expected	counted	maximum kinetic energy (eV)
10^{-9}	2.013647×10^{4}	20161	0.799568
10^{-8}	2.013647×10^{5}	200275	0.799601
10^{-7}	2.013647×10^{6}	2012743	0.799601
10^{-6}	2.013647×10^{7}	20145075	0.799605

Observation 3.2

intensity raises the number of photoelectrons, not the upper limit of one electron's energy.The log slope of the counts was $\mathbf{1.000113}$, and the maximum kinetic energy never exceeded $h\nu - \varphi = \mathbf{0.799605}$ eV at any intensity——kinetic energies were placed uniformly between 0 and the limit as an example; only the limit is set by one photon's energy.

4. Two Clocks

Computation 4.1: **with atomic cross-section $\sigma = 10^{-20}$ m², intensity was moved over 12 decades from 10^{-9} to 10^{3} W/m².**

intensity (W/m²)	wave gathering time (s)	mean wait (s)	ratio
10^{-9}	3.685006×10^{10}	4.966115×10^{-5}	7.420300×10^{14}
10^{-6}	3.685006×10^{7}	4.966115×10^{-8}	7.420300×10^{14}
10^{-3}	3.685006×10^{4}	4.966115×10^{-11}	7.420300×10^{14}
1	3.685006×10^{1}	4.966115×10^{-14}	7.420300×10^{14}
10^{3}	3.685006×10^{-2}	4.966115×10^{-17}	7.420300×10^{14}

Observation 4.2

this is the core. Dimming the light does not change the ratio of the two times.At every intensity over the 12 decades the ratio was 7.420300×10^{14}, equal to the value of $(A/\sigma)\eta(\varphi/h\nu)$——intensity acts equally on both clocks, so the wave's delay neither stands out in weak light nor vanishes in strong light. What sets the gap is the ratio of the receiving area to one atom's cross-section.

5. Generating Wait Times at Random

Computation 5.1: **at intensity 10^{-6} W/m², with release rate $R = 2.013647 \times 10^{7}$ per second, 1000000 wait times were drawn from the exponential distribution.**

quantity	value
mean wait	4.968379×10^{-8} s ($1/R = 4.966115 \times 10^{-8}$)
median	3.446618×10^{-8} s ($\ln 2/R = 3.442248 \times 10^{-8}$)
slowest wait	7.564253×10^{-7} s
wave gathering time	3.685006×10^{7} s (1.167708 years)
fraction released before the wave's time	1.000000
slowest / wave's time	2.052711×10^{-14}

Observation 5.2

at 10^{-6} W/m² the wave gathers for 1.167708 years, while the photoelectron comes out after 4.966115×10^{-8} s on average.In all 1000000 trials the first photoelectron came out before the wave's gathering time, and even the slowest was 2.052711×10^{-14} of it——the wait is exponentially distributed, with mean and median matching $1/R$ and $\ln 2/R$.

6. The Separator and What Is Not Said

Observation 6.1

the separator is whether the energy is received over one atom's cross-section or over the whole receiving surface.The wave's clock runs at the rate one atom's cross-section collects energy, and the photon's clock at the rate photons reach the whole surface——intensity acts equally on both, and what remains is the area ratio A/σ, the quantum efficiency, and the ratio of work function to photon energy.

Observation 6.2

what is not said.The cross-section, surface, quantum efficiency, wavelength and work functions are example values, not those of real metals. Photoelectron energies were placed uniformly as an example——no experimental values for the delay are given, and no common root with 448 or 270 is claimed.

7. Census and Closing

1. **slopes 4.139190×10^{-15} and 4.140939×10^{-15} V·s, ratio 0.999578** (Computation 2.1): **h/e whatever the work function.**
2. **log slope 1.000113, limit 0.799605 eV** (Computation 3.1): **what grows is the number.**
3. **ratio of the two times 7.420300×10^{14} unchanged over 12 decades** (Computation 4.1): **the core.**
4. **wave's time 1.167708 years, mean wait 4.966115×10^{-8} s** (Computation 5.1): **at 10^{-6} W/m².**
5. **all 1000000 trials before the wave's time** (Observation 5.2): **slowest 2.052711×10^{-14} of it.**
6. **one atom's cross-section or the whole surface** (Observation 6.1): **the separator; Papers 448, 668, 270, 1005.**

Closing: **Dimming the light does not change the ratio of the wave's charging time to the wait for the first photoelectron.The stopping-voltage lines of surfaces with work functions 2.0 eV and 4.5 eV share the slope h/e (ratio 0.999578), and what intensity increased was the number of photoelectrons, while the energy limit 0.799605 eV stayed fixed——the ratio of the time for a wave to gather one work function through one atom's cross-section to the mean wait for the first photoelectron stayed at 7.420300×10^{14} over 12 decades of intensity.At 10^{-6} W/m², against the wave's 1.167708 years, the mean wait was 4.966115×10^{-8} s, and 1000000 random trials never waited for the wave's time——what sets the ratio is the area ratio and the quantum efficiency.The separator is whether the energy is received over one atom's cross-section or over the whole receiving surface.Placed among the earlier papers——Paper 448 showed that one photon's energy decides whether a bond breaks and left speed aside, and in another item of the same scope note Paper 668 counted the difference in luminescence times. Paper 270 counted the carriers of h/e, and Paper 1005 the ratio of stimulated to spontaneous emission. Here the time until light releases an electron was counted as the ratio of the wave's clock to the photon's clock.To be honest——the cross-section, surface, quantum efficiency and work functions are example values, and experimental delays and real metals are not treated.**

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