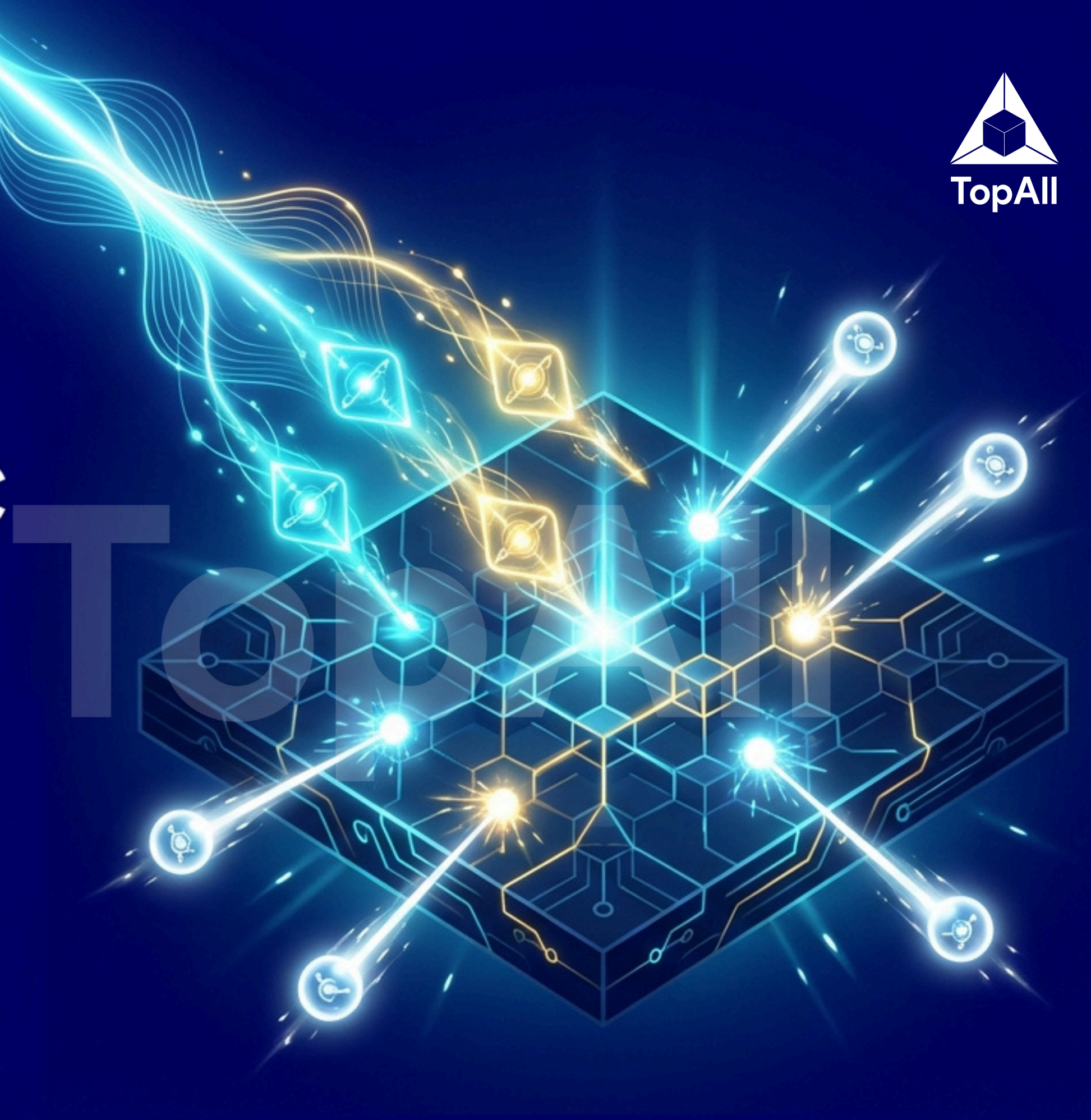
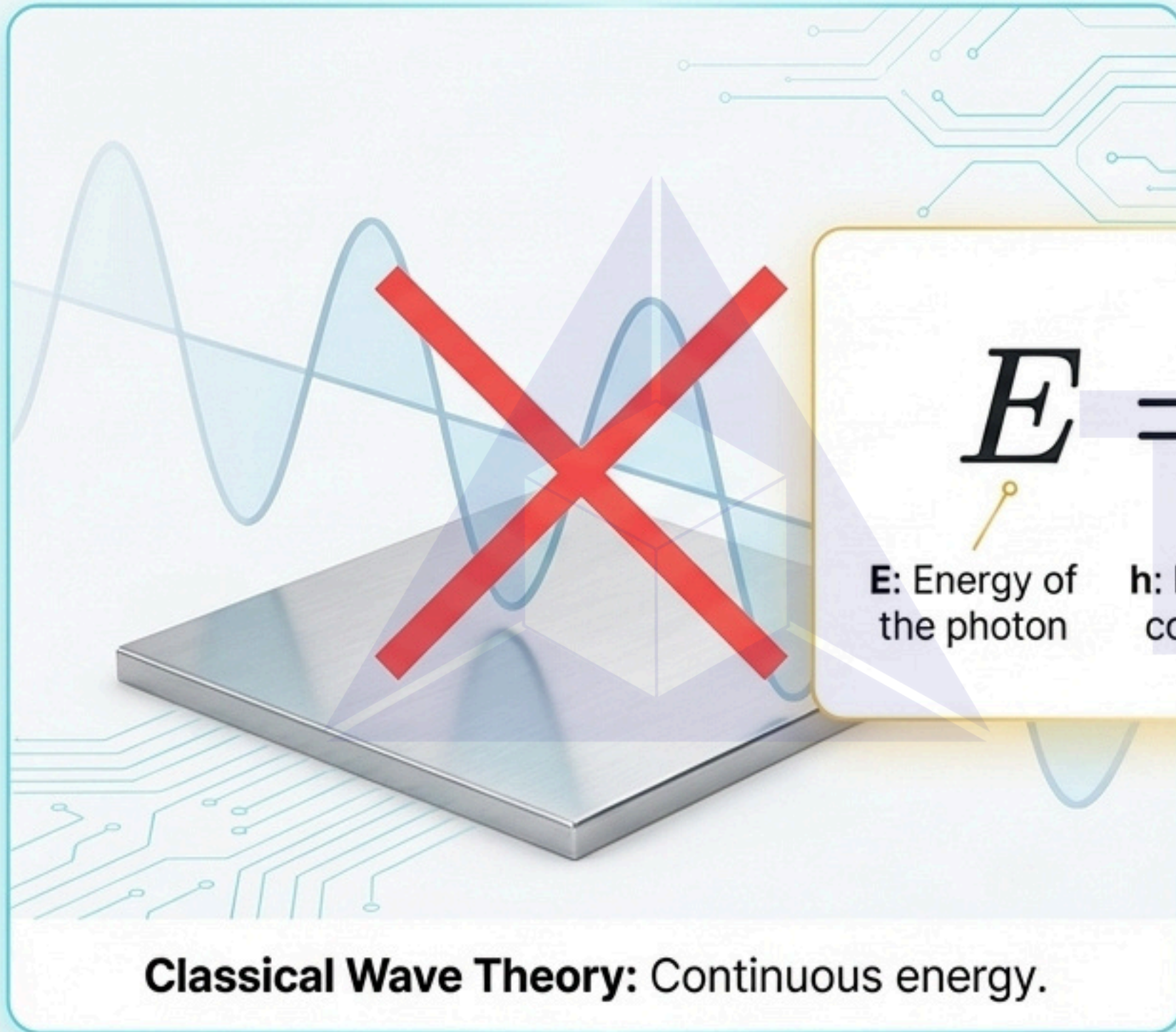


# Einstein's Photoelectric Equation

The quantum explanation  
of the photoelectric effect

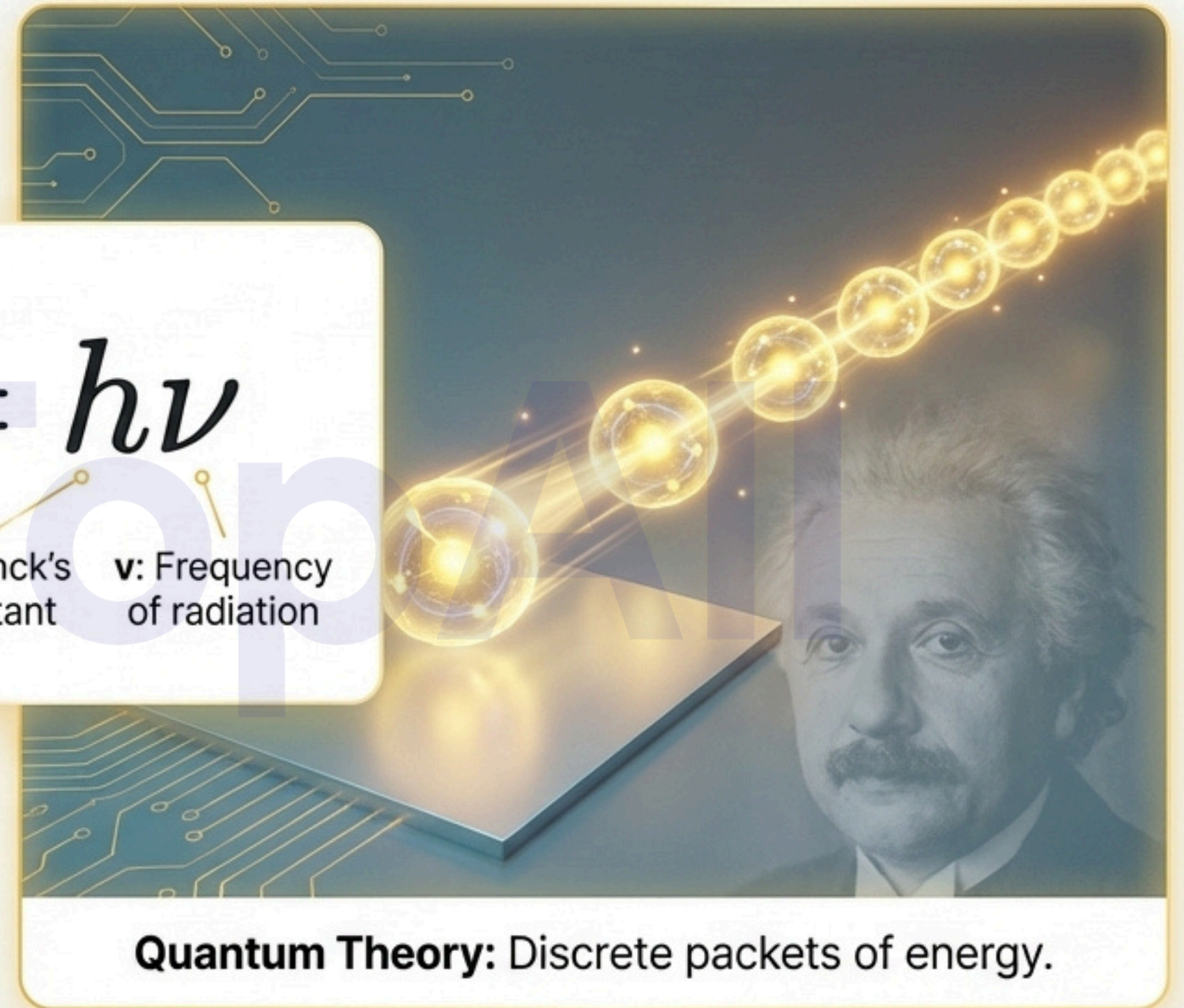


# The Quantum Nature of Radiation



A diagram illustrating Classical Wave Theory. It shows a blue sine wave representing continuous energy waves hitting a grey rectangular metal plate. A large red 'X' is superimposed over the wave, indicating that this theory is being rejected or contrasted with the quantum theory shown on the right.

**Classical Wave Theory:** Continuous energy.



A diagram illustrating Quantum Theory. It shows a series of yellow, glowing spheres (photons) moving in a straight line towards a grey rectangular metal plate. In the background, a portrait of Albert Einstein is visible. The overall theme is discrete packets of energy.

**Quantum Theory:** Discrete packets of energy.

$$E = h\nu$$

**E:** Energy of the photon

**h:** Planck's constant

**$\nu$ :** Frequency of radiation

Energy comes in **indivisible** units. You cannot have half a photon.

# The Mechanics of Emission



Total incoming energy must exactly equal the energy spent plus the energy kept.



# You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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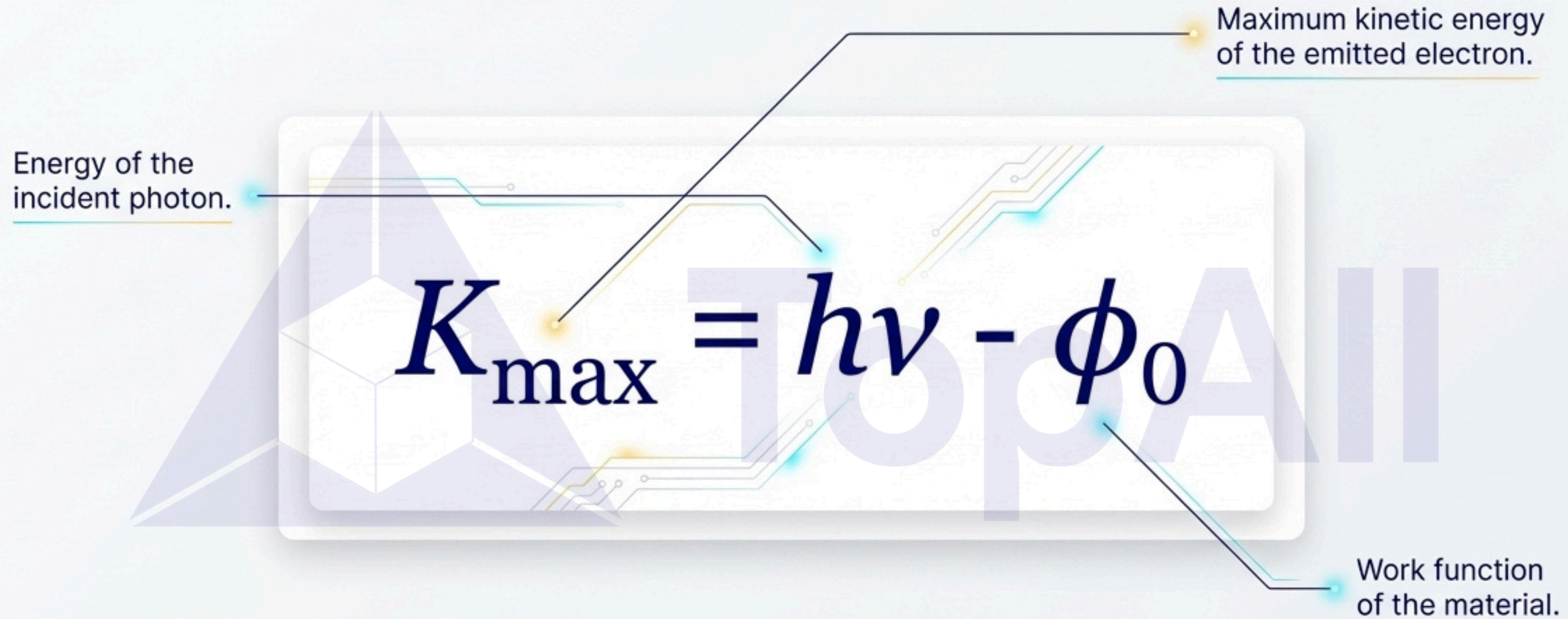
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- » Free Study Material, Videos & Infographics
- » Push Your Limits with Level-Based Challenges
- » Climb the Leaderboard Among Fellow Aspirants
- » Practice Unlimited MCQs for NEET & JEE
- » Get Clear Explanations, Not Just Marks
- » Track Your Performance Smarter



# Einstein's Photoelectric Equation



The diagram features the equation  $K_{\max} = h\nu - \phi_0$  centered on a white rectangular background with a subtle circuit pattern. Three callout lines with colored dots point to specific parts of the equation: a blue line from the left points to  $h\nu$ , a yellow line from the top right points to  $K_{\max}$ , and a blue line from the bottom right points to  $\phi_0$ . Each callout is accompanied by a text label and a horizontal underline.

Energy of the incident photon.

Maximum kinetic energy of the emitted electron.

Work function of the material.

$$K_{\max} = h\nu - \phi_0$$

This simple statement of energy conservation perfectly models all experimental observations of the photoelectric effect.

# Defining the Minimum Cut-off

## Step 1:

Kinetic energy cannot be negative.  
Therefore,  $K_{\max} \geq 0$ .

## Step 2:

Applying Einstein's equation, we know  
 $h\nu - \phi_0 \geq 0$ .

## Step 3:

Mathematically, this means  $h\nu \geq \phi_0$ .

The Threshold Frequency ( $\nu_0$ ) occurs exactly at the boundary where  $h\nu = \phi_0$ .

$$\nu_0 = \frac{\phi_0}{h}$$

Below  $\nu_0$ , a photon simply doesn't have enough energy to pay the work function 'toll'. No emission occurs, regardless of light intensity.

# Connecting Equation to Experiment

## The Algebra

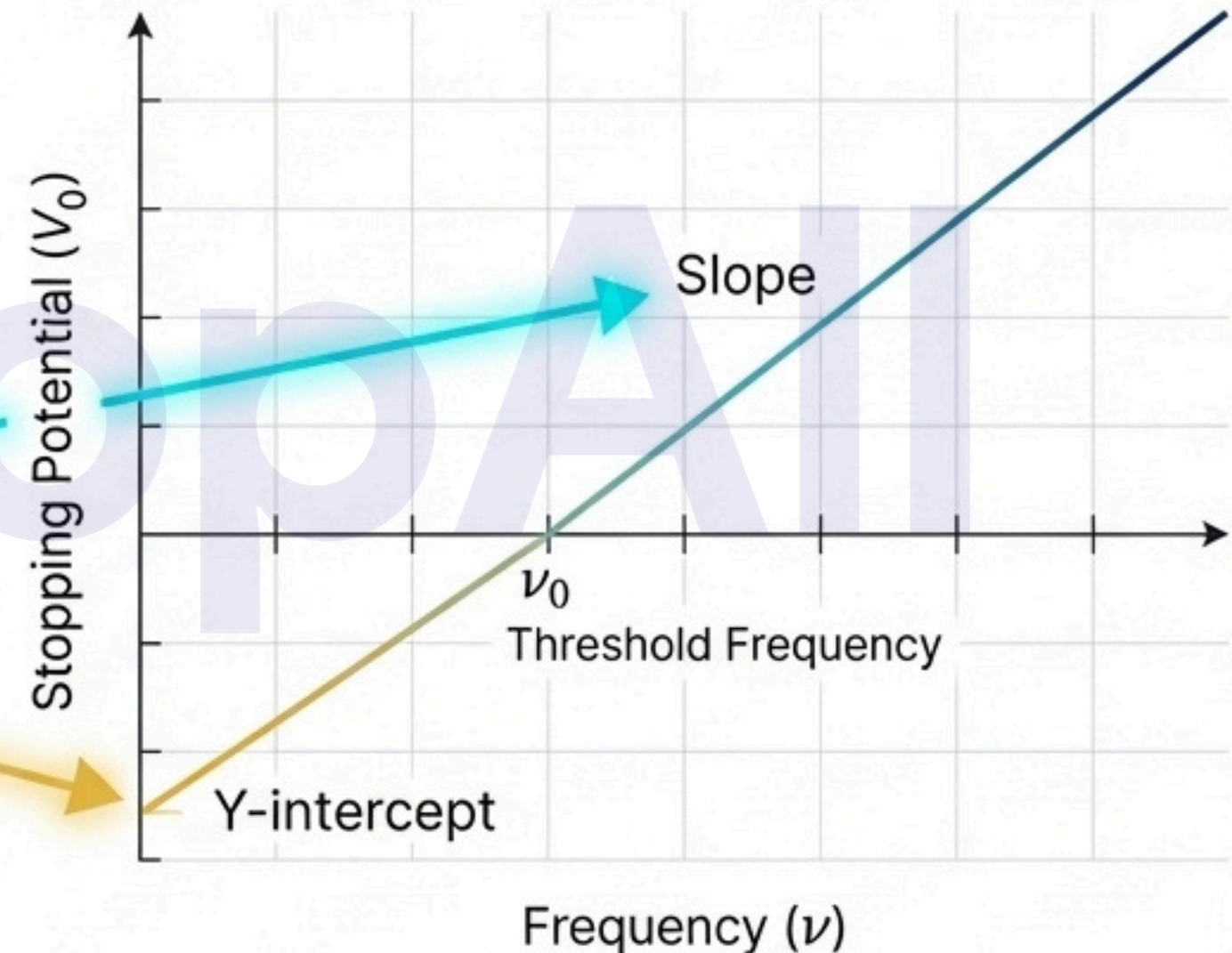
Start:  $K_{\max} = h\nu - \phi_0$

Substitute Stopping Potential ( $K_{\max} = eV_0$ )

$$V_0 = \frac{h}{e}\nu - \frac{\phi_0}{e}$$

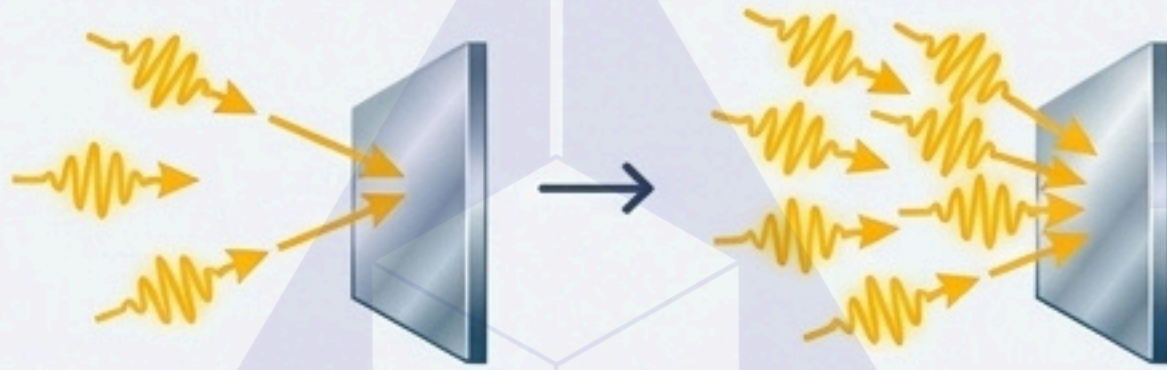
Rewriting the equation to match the straight-line graph format of  $y = mx + c$ .

## The Geometry



# The Quantum Triumph

## Increasing INTENSITY



Increases the **NUMBER** of photons arriving per second.

**Result:** More electrons emitted (higher current), but with the **SAME** maximum kinetic energy.

## Increasing INTENSITY



Increases the **ENERGY** of each individual photon.

**Result:** Emitted electrons have a **HIGHER** maximum kinetic energy, but the number of electrons stays the same.

The particle model perfectly explains what classical waves could not.



# You've Learned the Theory.

## Now Let's Test It.

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