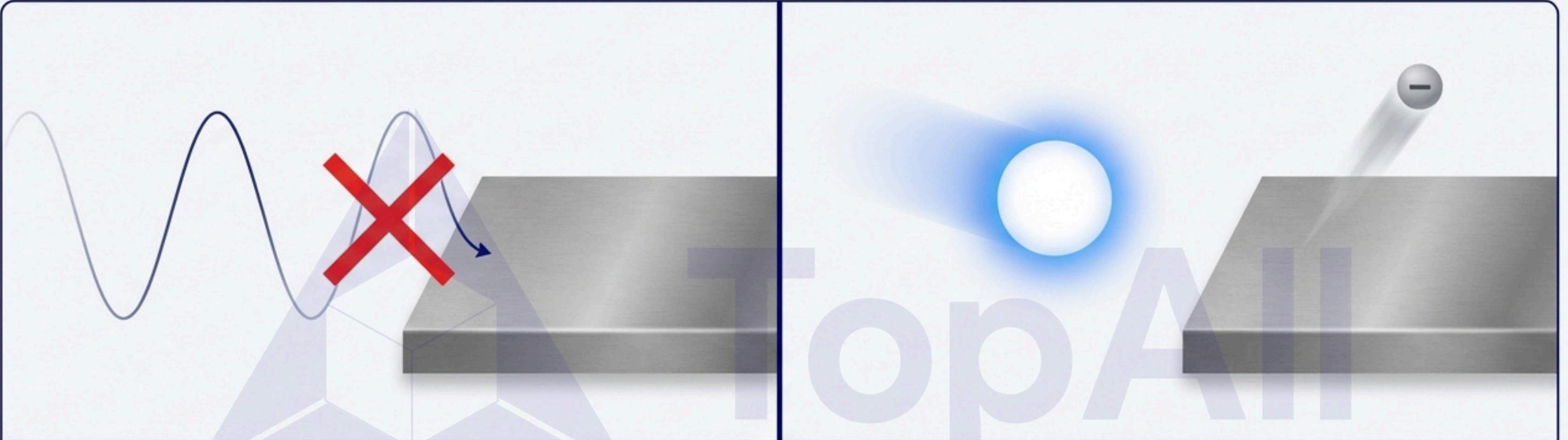


The Photon

Light as a particle



The Photoelectric Problem



Why classical waves failed

The continuous wave theory of light could not explain the instantaneous nature of the photoelectric effect or the existence of a threshold frequency.

The quantum shift

Einstein proposed a radically new picture: radiation is built of discrete, quantized units of energy. Light interacts with matter as a stream of particles.

Anatomy of a Photon



Energy

$$E = h\nu = hc/\lambda$$

Every photon's energy is strictly dictated by its frequency (ν).
(h = Planck's constant).



Momentum

$$p = h\nu/c = h/\lambda$$

Despite having no rest mass, photons carry definite momentum, allowing them to exert physical force.



Speed

c

All photons travel at the exact same speed in a vacuum (3×10^8 m/s), regardless of their frequency.



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$$E=mc^2$$



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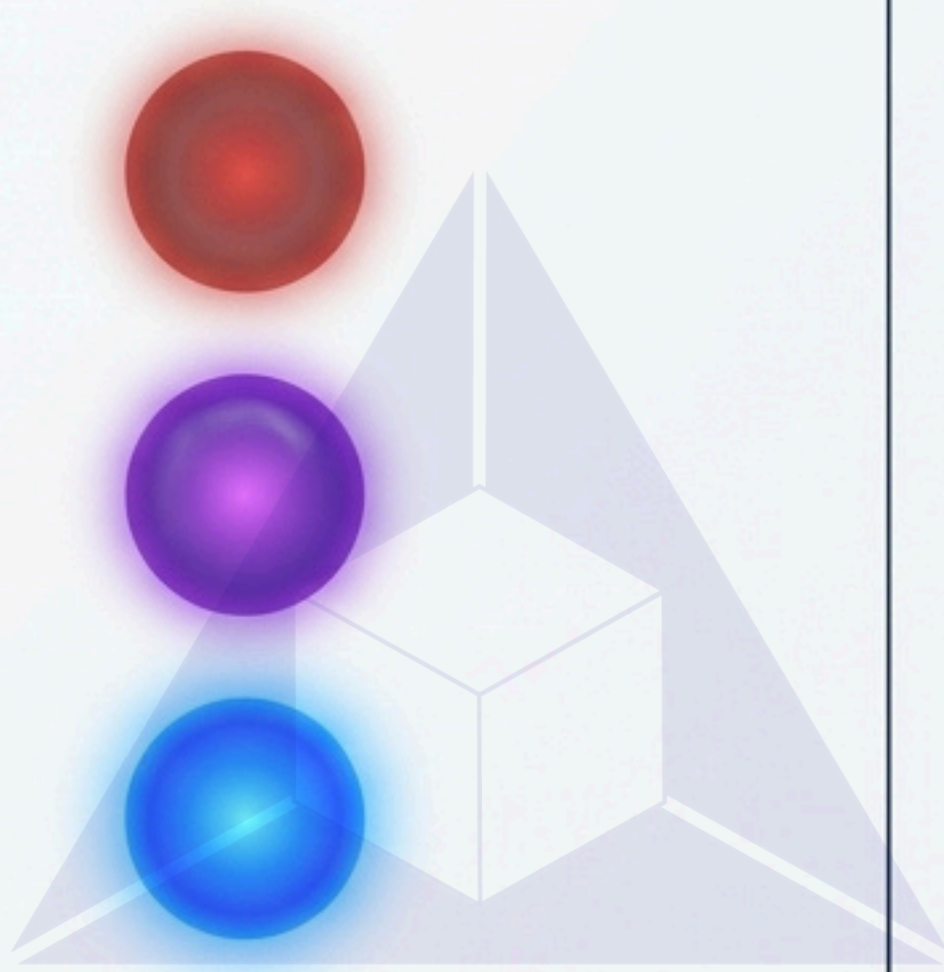
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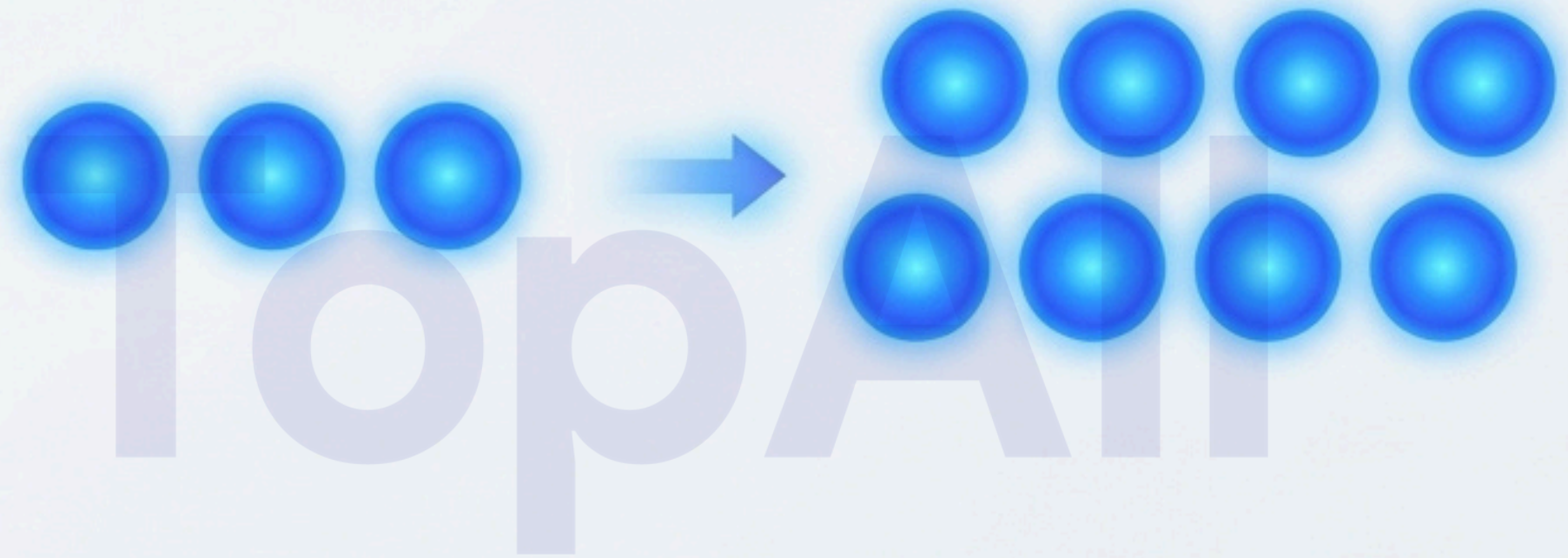


Intensity vs. Energy



Changing Frequency (ν)

Changes the energy of *each individual photon*. If frequency increases, the energy per packet increases.

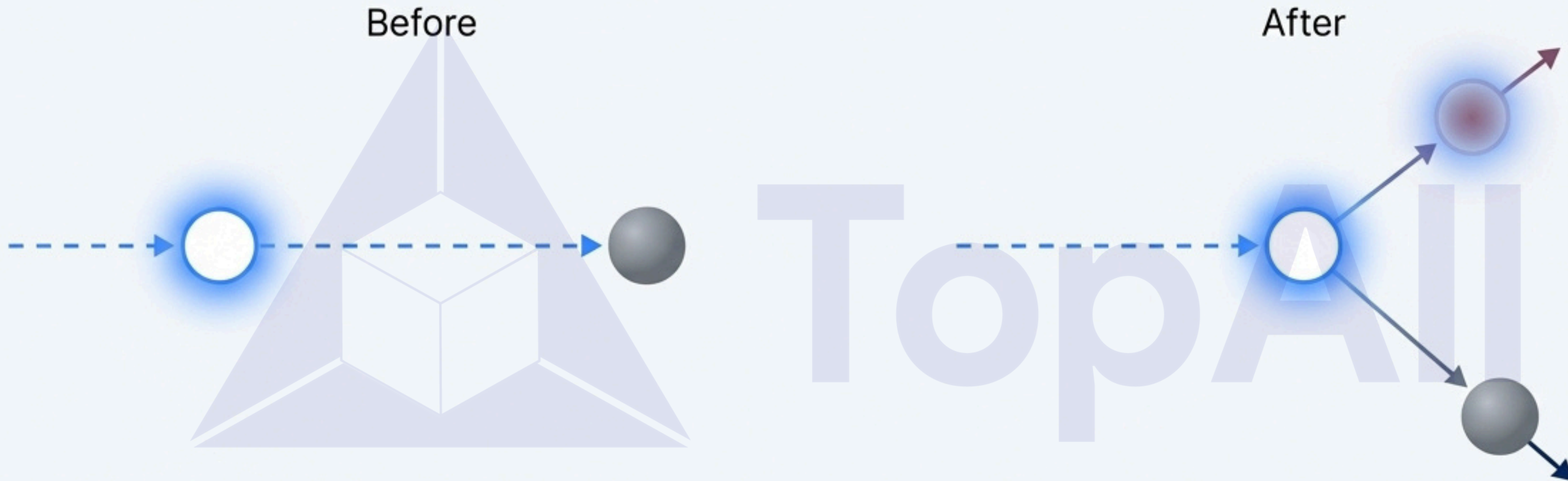


Changing Intensity (I)

Changes the *number of photons* crossing an area per second. Higher intensity simply means a higher photon count. The energy of each individual photon remains exactly the same.

Photon-Particle Collisions

When a photon collides with a subatomic particle (like an electron), it behaves exactly like a physical billiard ball.



Total Energy is Conserved. ($E_{\text{initial}} = E_{\text{final}}$)

Total Momentum is Conserved. ($p_{\text{initial}} = p_{\text{final}}$)

Note: While energy and momentum are strictly conserved, the absolute number of photons may not be (photons can be completely absorbed or new ones created).

Chapter 11.7 Summary



Particle Behavior

In interaction with matter, radiation behaves as a discrete stream of particles called photons.



Energy Dependence

A photon's energy ($E = h\nu$) depends *only* on its frequency or wavelength, never on the light source's intensity.



Charge & Fields

Photons are completely electrically neutral. They cannot be deflected by electric or magnetic fields.



Intensity Definition

Increasing the intensity of light of a given wavelength solely increases the number of photons emitted per second.



You've Learned the Theory.

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