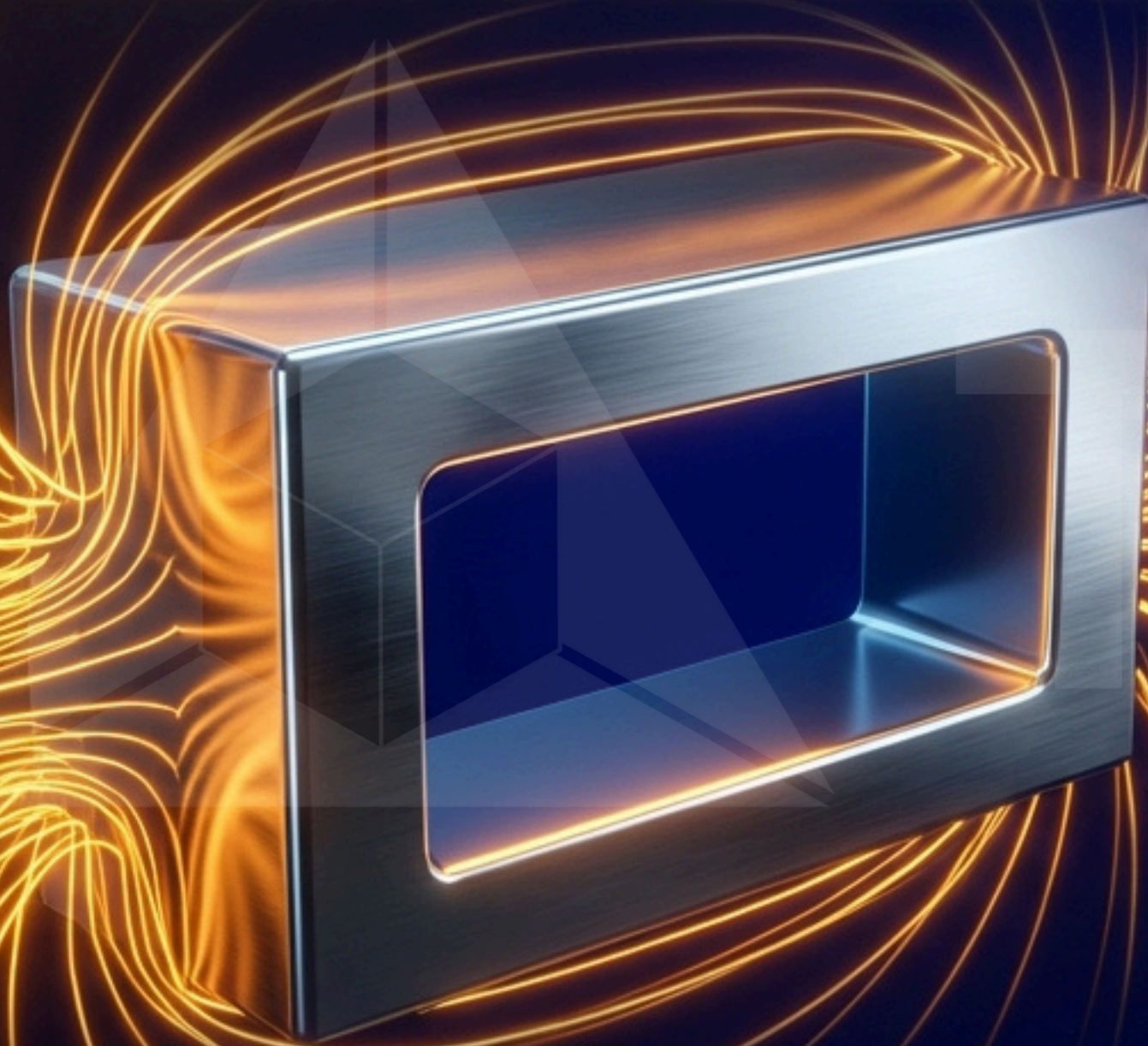


Why is the electric field zero inside a conductor?

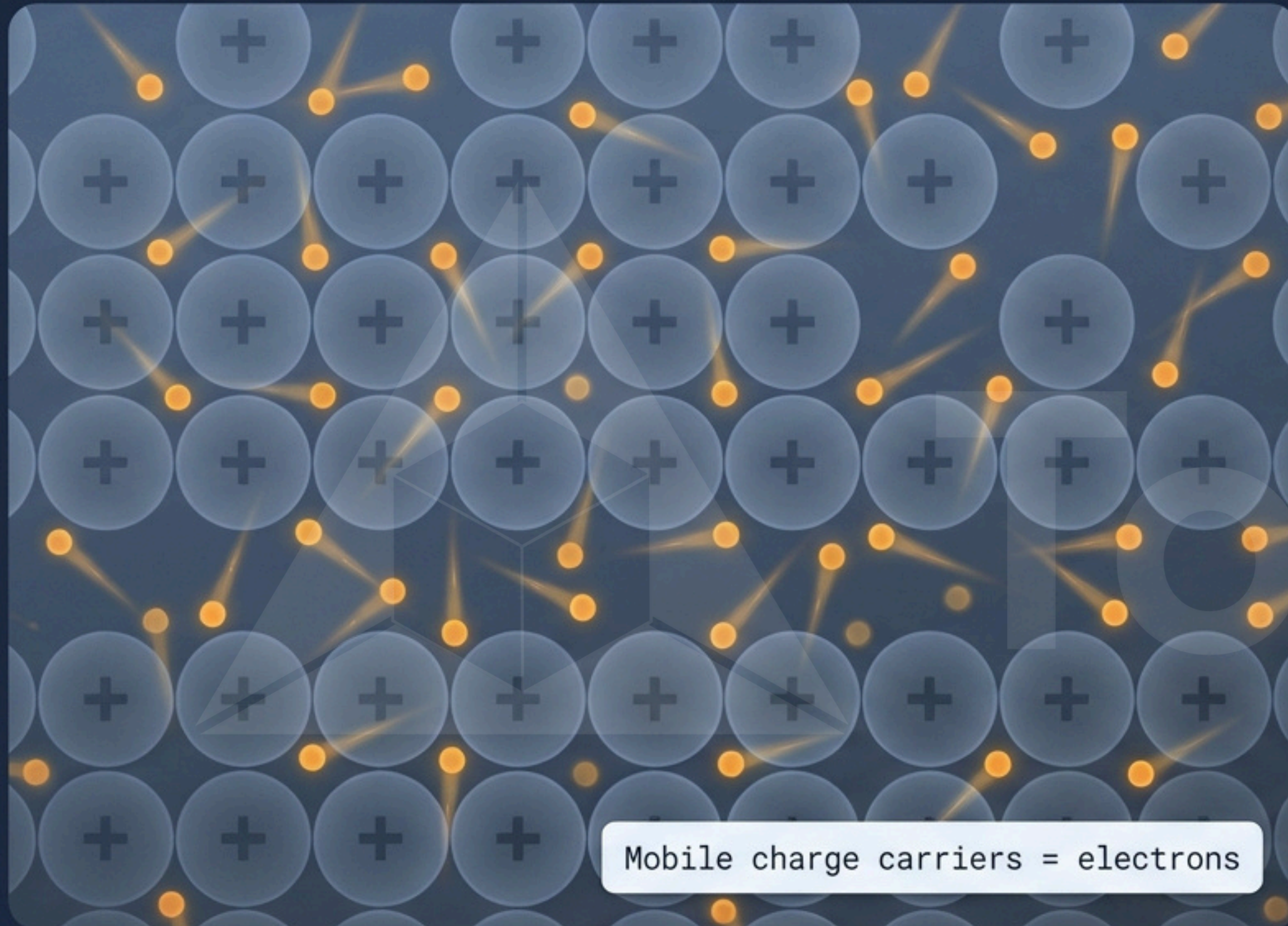


The Paradox: You can place a solid metal block in a raging, immensely powerful external electric field... but the exact center of that metal block experiences absolute zero force.

The Question: Where does the field go? And how does the metal know how to protect its interior?

The Secret: It's not magic. It's the defining property of metallic solid conductors: **Electrostatic Equilibrium.**

The Free Electron 'Gas'



Mobile charge carriers = electrons

The Anatomy of a Metal

In metallic solid conductors, the outer (valence) electrons part away from their atoms.

Mobile Charge Carriers

These electrons are free to move anywhere *within* the metal, but cannot easily leave the surface.

The Fixed Grid

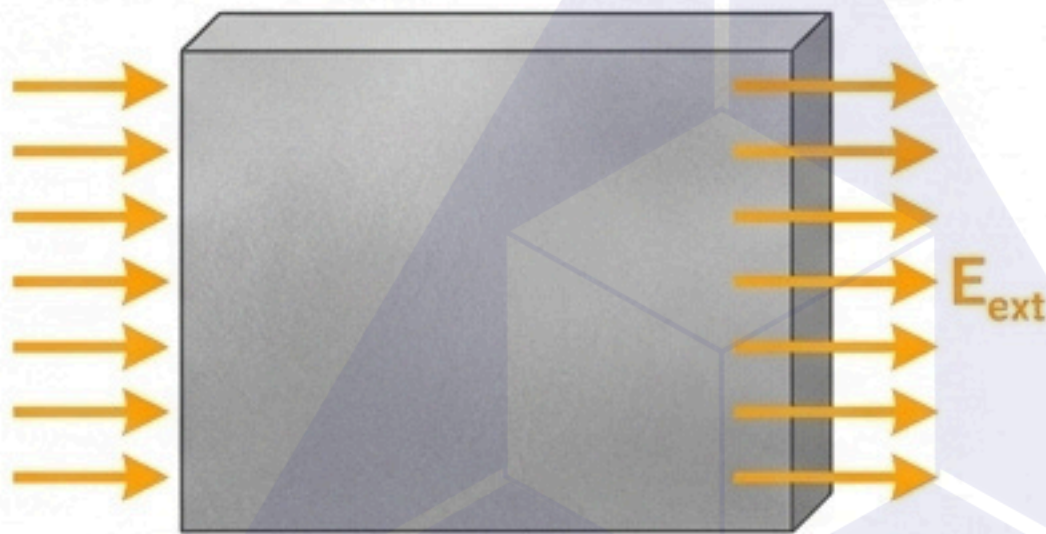
The positive ions (made up of nuclei and bound electrons) remain held tightly in fixed positions.

In an External Field

When an electric field E is applied, this electron "gas" experiences a force and drifts against the direction of the field.

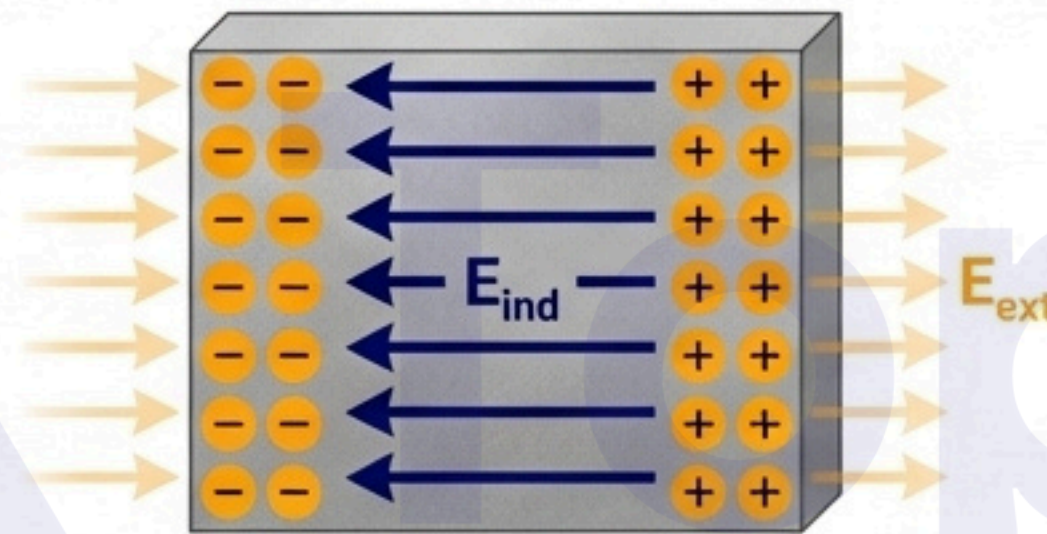
Reaching Electrostatic Equilibrium

Step 1: The External Field



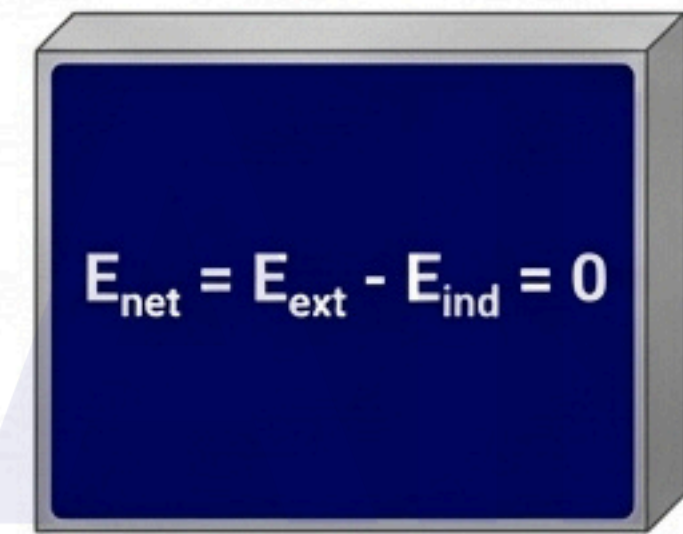
An external field is applied to a neutral conductor.

Step 2 & 3: Migration & Internal Field



Free electrons drift opposite to the field, creating an internal induced field that directly opposes E_{ext} .

Step 4: Equilibrium



Electrons stop moving only when E_{ind} perfectly cancels E_{ext} . Inside, the net field is strictly zero.



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

$$E=mc^2$$



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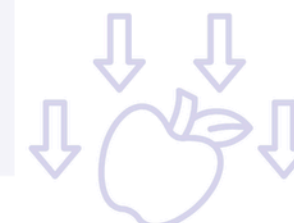
Practice Now



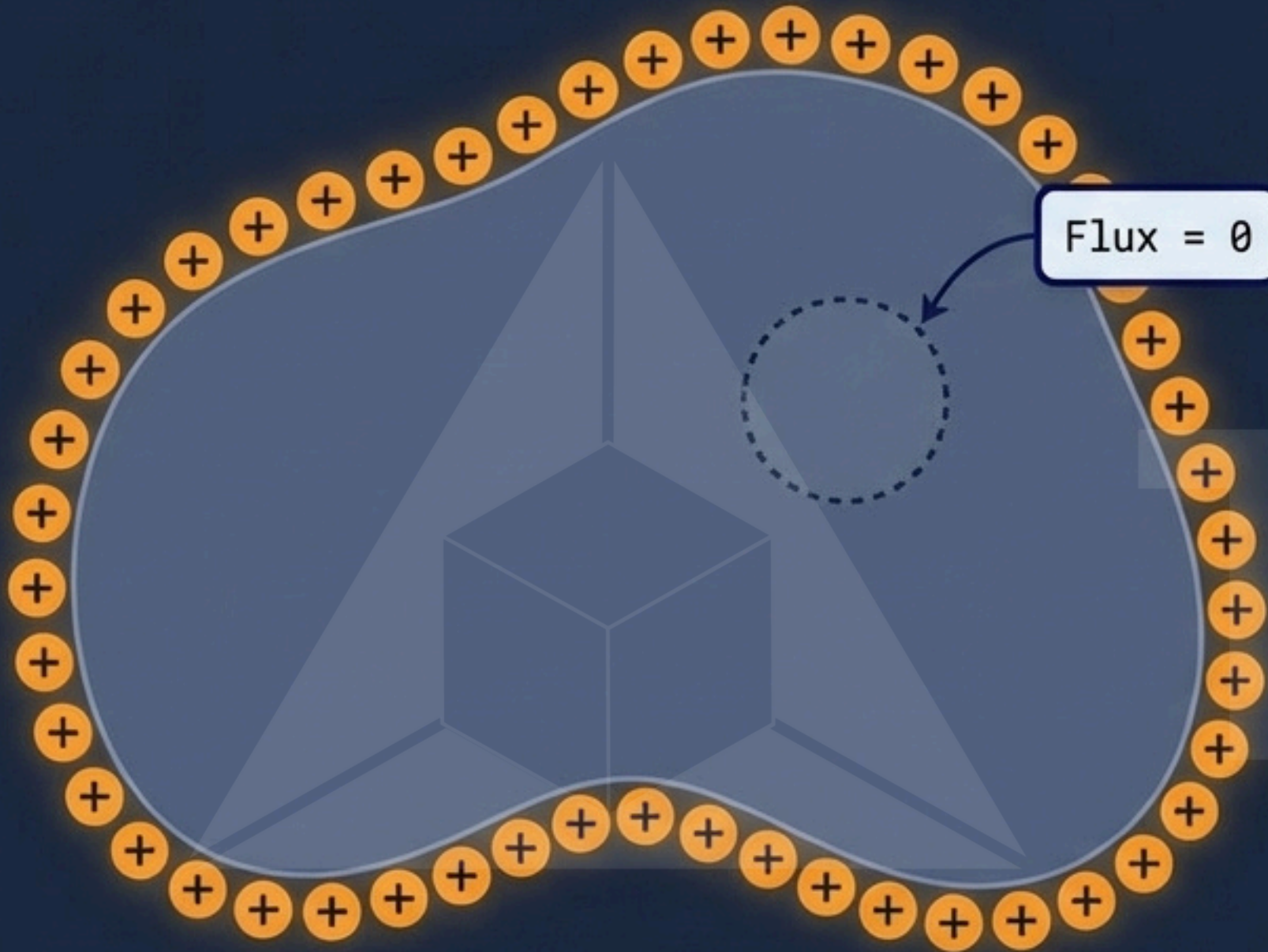
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Excess Charge Resides Only on the Surface



$V = \text{constant everywhere inside \& on surface}$

Gauss's Law Proof

- Consider any arbitrary volume element inside the conductor.
- Since $\mathbf{E} = \mathbf{0}$ everywhere inside, the total electric flux through the bounding surface is zero.
- By Gauss's law, the enclosed net charge must be zero.

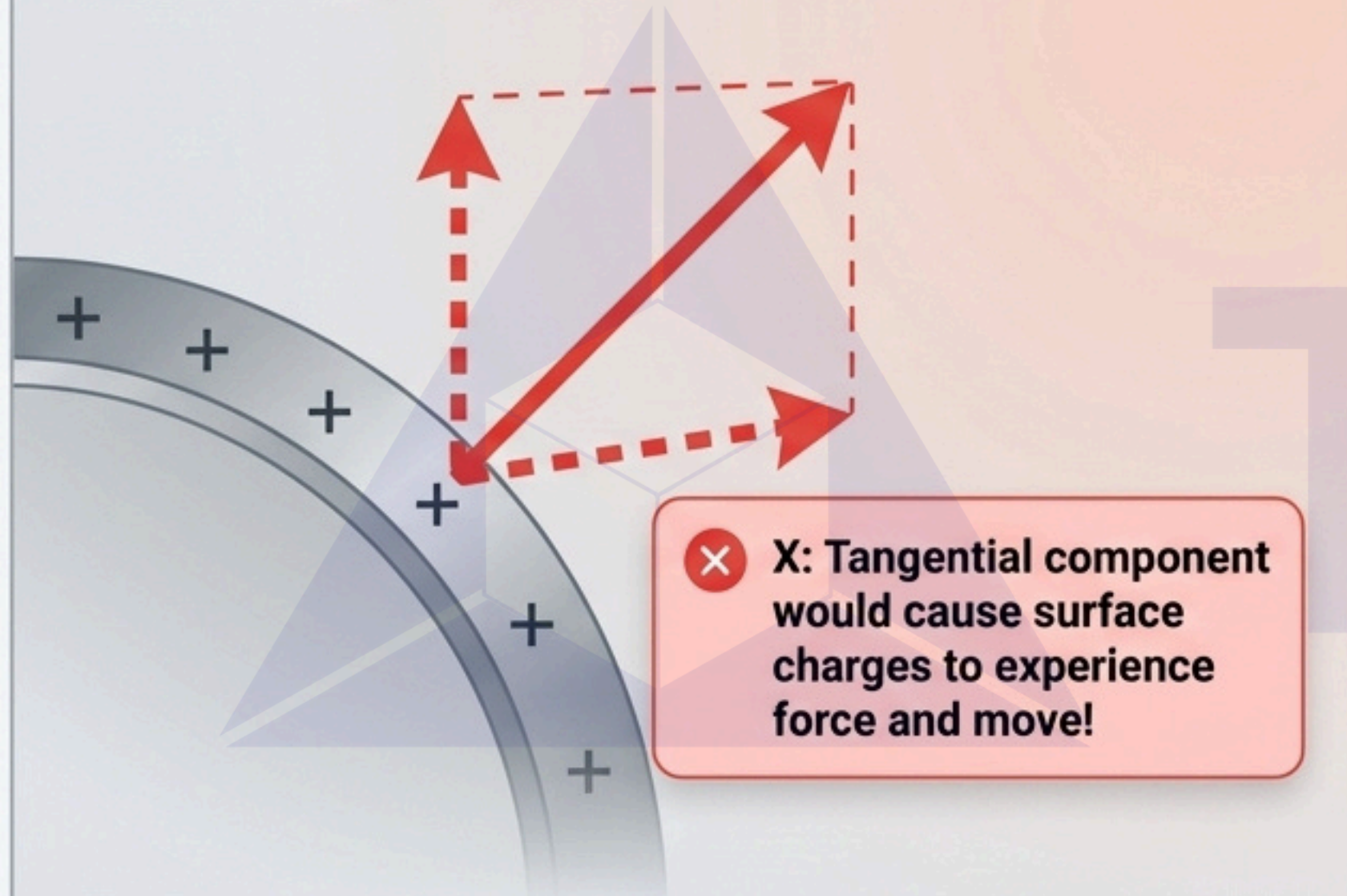
The Consequence: Any excess charge given to a solid conductor has nowhere to go but the outermost skin.

Constant Potential

Because $\mathbf{E} = \mathbf{0}$ inside, no work is done moving a test charge within the volume. Therefore, the electrostatic potential (V) is constant throughout the entire volume and has the same value as on its surface.

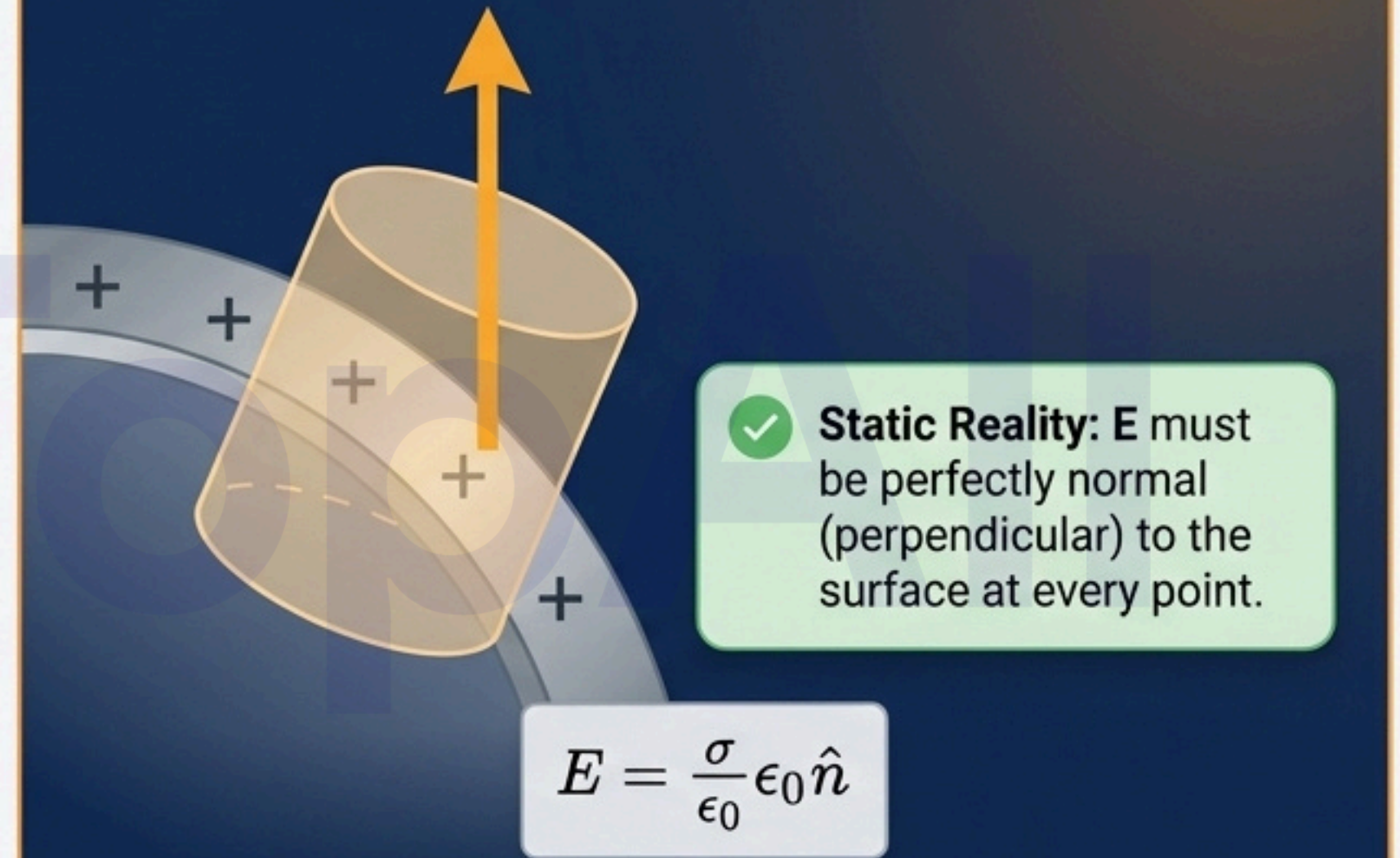
The Field is Normal to the Surface

The Contradiction



Why Perpendicular? In a static situation, there can be no tangential force. Free charges are at rest.

The Reality



Where σ is surface charge density and $\hat{n}$ is the outward normal unit vector.

Electrostatic Shielding: The Perfect Safe Room

The Phenomenon:

Whatever the size or shape of the cavity, and whatever the external electric fields, the field inside a hollow cavity is always zero.



$E = 0$. Absolute Shielding

The Mechanism:

All charges reside only on the outer surface. Induced charges distribute perfectly to cancel external influences, protecting sensitive instruments inside.



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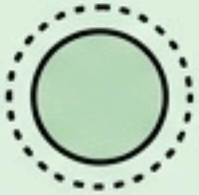
Key Takeaways: Electrostatics of Conductors

Master the core properties for electrostatic equilibrium:



Verify

The electric field is zero everywhere inside the conductor.



Locate

All excess charge resides exclusively on the outer surface.



Confirm

The electric field just outside is normal to the surface ($\mathbf{E} = \sigma / \epsilon_0 \hat{\mathbf{n}}$).



Calculate

Potential (V) is constant throughout the volume and matches the surface value.



Apply

Electrostatic shielding means the field inside any charge-free cavity is always zero.

Exam Trap: Thinking potential (V) is zero inside.

Truth: E is zero, V is constant!



You've Learned the Theory.

Now Let's Test It.

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